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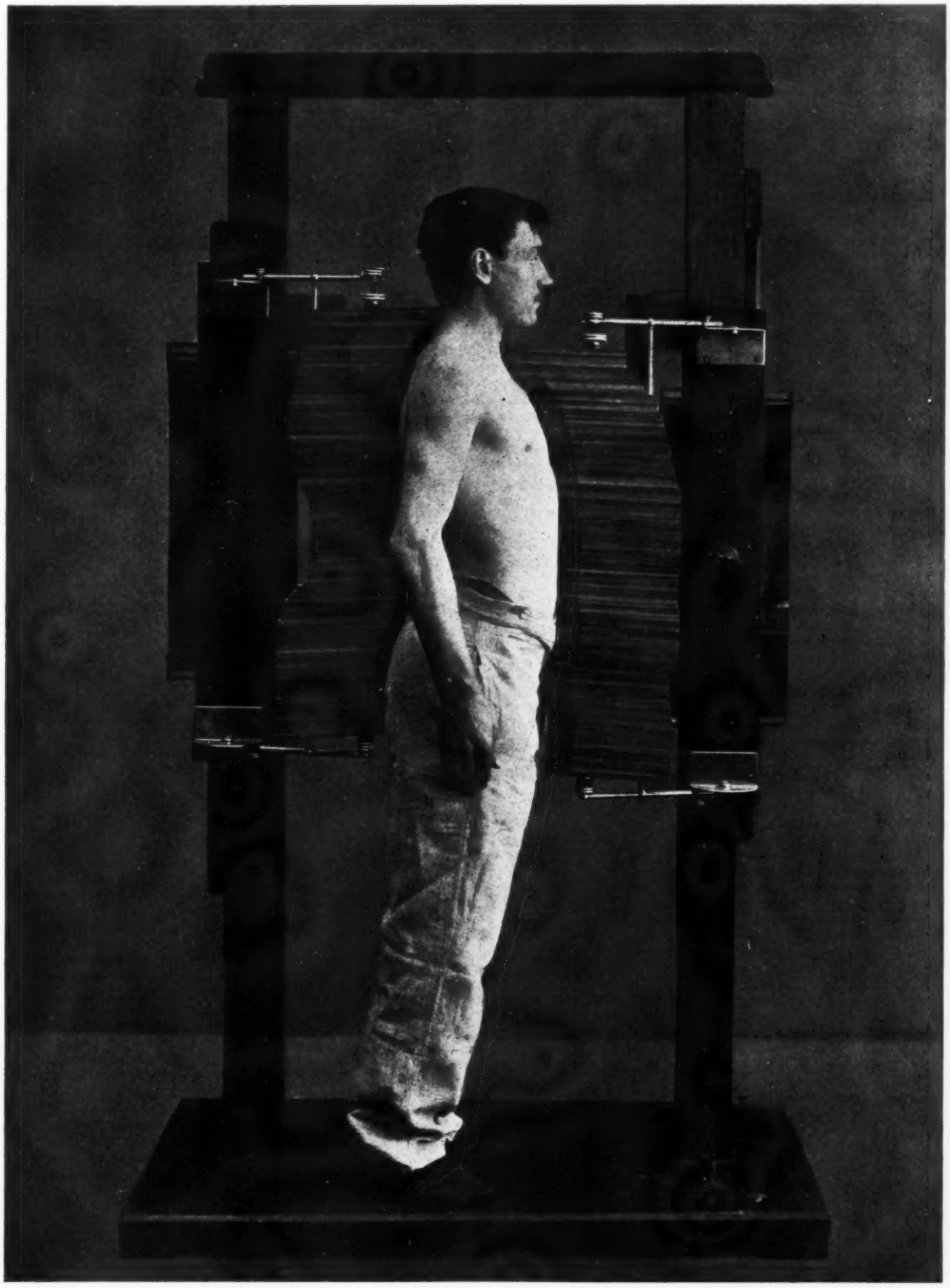


THE DEMENY CONFORMATOR. AN INSTRUMENT THAT ASSISTS IN PHYSICAL EXAMINATIONS.—[See page 292.]

Atoms and Ions—II*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O.M., F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2052, Page 274, May 1, 1915

IN opening his discourse the speaker said that, on the previous occasion, he had shown that if a discharge-tube were fitted with a fluorite window, the light which traversed this window was capable of endowing air with conductivity. He had also shown that on placing a thin plate of quartz before this window the conductivity of the adjacent air vanished; and, further, that if the air taken for investigation were drawn, not from the immediate surface of the fluorite, as in the original experiment, but from a region a few millimeters away, no conductivity was apparent. This showed that the ionizing rays were wholly absorbed within a depth of 2 millimeters or 3 millimeters of air at normal pressure. The rays in question belonged, he said, to what was known as the Schumann region of the spectrum.

He had himself, Sir Joseph Thomson continued, been working on the radiation produced by Röntgen rays, in which the cathode rays originating them were much slower than usual. He had started with rays of which the energy (measured in a certain way, to be defined later) was represented by a few volts, and had gone up to energies corresponding to 3,000 volts. He had investigated the nature of the Röntgen radiation given out when the type of cathode ray was varied through the range stated. The observations made confirmed in a very remarkable way a view he had put forward three years ago as to the origin of the characteristic radiation. He had then suggested that the emission of characteristic radiation marked the return of a negative particle to an atom which had been previously ionized by being deprived of negative electricity. Every ionized atom, when it re-acquired a negative charge gave out a characteristic radiation, and the energy of this radiation measured the number of atoms ionized by the cathode rays. An atom could be ionized in divers ways by taking a negative particle from different parts of its structure. If the particle were taken from the surface of the atom, not much work would be required to ionize the atom, and when it re-acquired the charge it would correspondingly give out characteristic radiation of a very soft type. If, however, the ionization were affected by removing the negative particle from a point nearer the center of the atom, more work would be required, and when the charge was regained, the characteristic radiation would be of a "hard type." He had found it possible to get in this way a great number of different "characteristic radiations," by gradually increasing the energy of the cathode rays used.

The ultra-violet light which passed through quartz was able, the speaker continued, to make some gases conductive, but not others. Thus Steubing had found that mercury vapor exposed to "quartz" light possessed some small amount of conductivity. This was a very interesting fact, and the question arose as to what were the properties of a gas which determined whether it did or did not become a conductor when exposed to light of a particular wave-length. In the subjoined table, the results recorded in the second line were observed in experiments made by Frank and Hertz to determine the amount of work required to ionize the molecules of different gases; that was to say, the energy needed to separate a corpuscle from an atom. The ionizing energy given in the second line of the table was expressed as a certain number of volts, this number being the voltage through which a unit charge would have to fall to acquire the energy necessary to ionize the atom:

Element.....	Hg.	N.	O.	H.	Ar.	Ne.	He.
Ionizing energy (volts).....	4.9	7.5	9	11	12	16	20.5
λ.....	2536	1600	1333	1090	1000	750	600

From the table it appeared that, for ionization, mercury required an amount of energy represented by 4.9 volts, nitrogen 7.5 volts, and oxygen 9 volts. The inert gases argon, neon, and helium, in contradiction to what might have been anticipated from the brilliancy of the discharge through them, were more difficult to ionize. Mercury vapor was evidently by far the easiest to ionize of the elements tabulated, but were the table extended to include such electro-positive bodies as sodium and potassium, mercury would be shifted from its position of priority. Underneath the ionizing energy will be found values of λ, where λ denotes that wave-length of that light, which was connected with the ionizing energy immediately above it, by the "quantum law." Light, the lecturer proceeded, behaved in many respects as if it were made up of discrete bundles, each endowed with a definite amount of energy. This amount depended upon the wave-length of the light, the smaller the wave-length the greater being the energy in each bundle. The energy in each bundle was, in fact, proportionate to the number of vibrations made per second by that particular kind of light. The numerical relationship between the ionizing energy (expressed in volts, as already explained) and the wave-length was given by the relation

$$\text{I. V} = \frac{12.2 \times 1000}{\lambda}$$

where λ was expressed in Angstrom units, and it was from this expression that the wave-lengths given in the last line of the table had been calculated. In order, therefore, that light should render a gas conductive, the energy in each "parcel of light" must be equal to the energy required to ionize a particle of gas. Hence light with a wave-length of 2,536 Angstrom units should ionize mercury, and light of this wave-length would pass through quartz. On the other hand, to ionize nitrogen the wave-length must not exceed 1,600, and to light as ultra violet as this quartz was opaque, a wave-length of 1,800 being about as short a wave-length as quartz would pass. Fluorite, on the other hand, was transparent to light of as short a wave-length as 1,200 Angstrom units, and hence it was to be expected that oxygen and nitrogen might be ionized by light able to traverse fluorite. This light would not, however, ionize hydrogen, which required the wave-length to be less than 1,090, to which fluorite was opaque. It would be seen that these conclusions corresponded very well with the results of experiment, air being ionized by "fluorite ultra-violet," and mercury by "quartz ultra-violet," while the others were immune to both.

There was, however, more in it than this, for in the mercury spectrum the wave-length 2,536 corresponded to one of the most brilliant and important lines, and, as stated, 2,536 was the wave-length corresponding to the ionizing potential. In some recent experiments by Frank, in which mercury was ionized by cathode rays sent through different definite falls of potential, he found that the spectrum of the mercury showed no trace of the line at 2,536 wave-length so long as the fall of potential was 4.9 volts or under; but that when this fall was increased to 5 volts or a little more, the line began to make its appearance, and increased in intensity as the voltage fall was still further augmented. The appearance of this line in the mercury spectrum coincided, in short, with the use of cathode rays having the critical amount of energy. Ionization was therefore closely connected with radiation, and by measurement of the energy required for ionization it was possible to deduce the position of conspicuous lines in spectra.

Perhaps the most famous case of ionization produced by light capable of passing through quartz was that discovered by Stark, who found that anthracene vapor became conductive when exposed to "quartz ultra-violet" light. The effect could be clearly shown by submitting anthracene vapor, inclosed in a quartz vessel, to the light of a mercury lamp having a quartz bulb. In that case, an electroscope coupled up to one of two electrodes (the other being earthed) immersed in the vapor gave evidence of a distinct leak. This experiment however, gave rise to certain difficulties of a theoretical character. It was believed that conductivity was an atomic phenomenon, and did not depend in any way on what companions were associated with a particular atom, the ionizing potential being quite independent of these. The light which passed through quartz had a wave-length of, say, 2,000 Angstrom units, and, so far as is at present known, the only gas which could be ionized by light of this wave-length was mercury vapor. It was true that no figures existed for carbon, but no other hydrocarbon than anthracene was ionized by "quartz light," and it was thus difficult to understand why anthracene should be.

For his own part he was not convinced that the ionization found in the case of anthracene did not arise from quite a different cause than from the direct action of the light as exemplified in the ionization of air by the "fluorite" rays. In the last lecture he had shown that when "quartz light" fell on metals, the latter gave out negative electricity. It seemed possible that when exposed to ultra-violet light anthracene might polymerize fine dust being produced as one result of the change, and that this dust, when exposed to the action of ultra-violet light, might give out negative electricity, just as small particles of metal would do in the same circumstances. If this were so, the apparent conductivity of anthracene vapor would be due to the photo-electric effect of light on solid particles. The accuracy of this hypothesis might, perhaps, be tested by measuring the speed of the particle in an electric field; since, when a dust particle acted as an ion, its speed was only 1/1000 that of the positive particles produced in genuine ionization. Tyndall indeed had shown that by the action of light on certain vapors, clouds of small particles were produced, and if anything analogous to this took place with anthracene, we should have an explanation of its conductivity which would not conflict with views held to be well founded from other considerations.

The lecturer next considered quite a different method of making a gas conductive, the ionization being produced by splashing or bubbling. The pioneer experiments in this line had been made by Faraday, who had carried out a very remarkable research on the electricity produced when steam was forced through narrow passages, as in Lord Armstrong's hydro-electric machine. Next after Faraday came Lenard, who was led to the subject by the attempt to find some explanation of a long-known fact—viz., that the air at the foot of a waterfall was in a somewhat anomalous condition, many observations having shown such air to be very peculiar. Lenard found that a considerable amount of ionization arose whenever water fell and struck a solid obstacle. The ions thus produced were of a type rare in "ionic populations," where, in general, there was no middle class. Big ions were found in plenty moving with a velocity corresponding to a fall of 1 volt per centimeter, and also many small ions moving at a speed 1,000 time as great. There was, however, a lack of ions to fill up the intermediate gap, but the ions observed near the foot of a waterfall had this intermediate character.

Their production was extraordinarily susceptible to slight impurities in the water. With ordinary tap-water no ionization was produced by splashing, and till the importance of using extremely pure water was realized, Lenard found himself unable to repeat in Bonn observations made at Heidelberg, where the water supply was purer. The speaker had himself found it possible to detect by their effect on the ionization produced by splashing, the presence in water of traces of rosaniline, which could not be detected by the coloration produced. Further, if sulphuric acid were added to the water in small quantities, no ionization was produced by splashing; while if more acids were added, so as to get a stronger solution, ionization was again observed, but its sign was reversed from negative to positive. An addition of 1 part of acid to 2,000 of water was sufficient to effect this change of sign.

Splashing was, he continued, very analogous to bubbling. Lord Kelvin was the first to observe the negative electrification produced when air was bubbled through water. The phenomenon was, however, to be observed only with certain liquids, gasoline, for example, giving no ionization. In fact, liquids were divisible into two sharply separated classes, according as they did, or did not, show electrification by splashing or bubbling. The division was one which ran through a considerable number of properties. Some, such as water, the alcohols, and phenols, had a large surface tension, and an abnormal specific inductive capacity, this being much larger than calculated from Maxwell's law, according to which the specific inductive capacity should be equal to the square of the refractive index. This property these abnormal bodies retained even in the gaseous state, the specific inductive capacity of water and alcohol being enormous in comparison with the squares of their refractive indices.

He had himself suggested that the two classes of compounds differed, in that with those having an abnormal specific conductive capacity, the atoms of the molecule were oppositely charged with electricity, while in normal bodies the atoms of the molecule were individually neutral. It was only with the abnormal liquids that ionization occurred on splashing, none being found with the normal class.

The ionization produced by bubbling had an important bearing on another thorny question—viz., that of ionization by chemical action. When hydrogen was produced by the action of dilute acid on zinc, the reaction was necessarily accompanied by the bubbling of the gas through the liquid reagents. Many chemical actions were, in fact, accompanied by large amounts of electrification, and it was a question whether this was genuine ionization by the chemical action or merely another

* Reproduced from *Engineering*

aspect of ionization by bubbling. A large effect due to the latter cause was to be expected, as the bubbles were very small. It could not, indeed, be doubted that in a large number of cases it was this bubbling that was accountable for the whole of the electrification observed.

There were, however, other cases to which this explanation would not apply. One of these (still without any very thorough explanation) was the ionization produced when air was drawn over phosphorus. If a little phosphorus were placed in a tube through which air was sucked, then, if a collector in the tube were connected up to an electroscope, the latter indicated that the air which had passed over the phosphorus had become conductive. This might seem as simple a case of chemical action as we could have, but Block had shown that the matter was really rather complicated. The passage of the air over the phosphorus was accompanied by a faint luminosity, and by increasing the speed of the air current this luminous cloud could be drawn clear of the phosphorus, leaving a dark space between. Block found that if his collecting wire were placed in this dark space, there were no signs of conductivity; while if placed in the luminous cloud, there was conductivity. This green phosphorescent cloud was attributed to the further oxidation of a highly unstable oxide (P_3O_4) first formed.

This appeared to be a comparatively simple case of chemical action accompanied by conductivity, but there was, nevertheless, something exceptional about it, since similar chemical and light effects were to be observed with sulphur and arsenic, a similar luminosity and similar unstable oxide being formed, but without any trace of conductivity. There were, in fact, corresponding chemical and optical effects, but no ionization. This instance well illustrated the difficulties met with in connection with the question of ionization by chemical action. He had shown in the last lecture that hot solids gave out electricity. Many chemical reactions were accompanied by the formation of solids, which, if hot, would give out negative charges; but the ionization thus produced was not that of theoretical importance, and it was very difficult in the case of chemical reactions to separate these spurious types from the true. As matters stood, it would be premature to say whether or no ionization was ever directly produced by chemical action.

(To be continued.)

The Scientific Work of Prof. J. C. Bose

By Jakob Kunz, Ph.D.

In the realm of natural science we find three fundamental achievements of the human mind, three victories over the material world which has yielded to the searchlight of human thought three of her great secrets. The first great synthesis was that of Newton, who found in the law of gravity a common property of all ponderable matter and thus laid the theoretical foundations for mechanics and astronomy. A second great synthesis was carried out by Faraday-Maxwell, who came to the conclusion that light is an electro-magnetic phenomenon, that in a beam of light there are acting the same forces as operate between two electrified spheres and between magnets. If we observe the attractions and repulsions between electric charges and between magnets, the magnetic action of electric currents, the forces acting in dynamos, motors and transformers, and if we consider the large variety of phenomenon of light—the reflection, refraction, polarization, double refraction, rotation of the plane of polarization, and interference and diffraction of light with their wonderful color effects—we would hardly suspect a bond of unity to exist in all these phenomena. Nevertheless science has discovered the common bond of unity of all electro-magnetic phenomena. This scientific synthesis lead to the discovery of electric waves by H. Hertz, which are used specially in wireless telegraphy.

The third wide synthesis is that of Charles Darwin, who came to the conclusion that all living beings, plants, animals and men are connected with each other through a process of evolution and that they arose from the same source. There are other great triumphs of the human intelligence over the material world, as for instance in the organic and inorganic chemistry, and in other fields, but no other synthesis has been so general and far reaching as those mentioned. Prof. J. C. Bose's work is intimately connected with the last two synthesis; namely, the electro-magnetic nature of light, and the unity of all life on the surface of the earth. The electric waves predicted with all their properties by Maxwell, were discovered by H. Hertz in 1887. These waves about three meters long showed reflection, refraction and polarization like a beam of light. But they were still about ten million times longer than the beam of visible light. Prof. Bose has thrown a bridge over the gulf by creating and studying electric waves of about 6 millimeters, the longest heat and light waves known at the present time being about 0.6 millimeters. There still exists a very small gap, but there is no doubt that waves of the same wave length produced by electrical methods and by heat and light radiators will be absolutely identical. Prof. Bose showed that these short electric waves have the same property as a beam of light, exhibiting reflection refraction, even total reflection; through a black crystal, double refraction polarization and rotation of the plane of polarization. The thinnest film of air is sufficient to produce total reflection of visible light with its extremely short wave lengths. But with the new electric waves which he discovered, Bose showed that the critical thickness of the air-space was determined by the refracting power of the prism and by the wave length of the electric oscillations. He found a special crystal, Nemalite, which exhibits the polarization of electric waves in the very same way as a beam of light is polarized by a Tourmaline crystal. The rotation of the plane of polarization was demonstrated by Prof. Bose by means of a contrivance twisted like a rope and the rotation could be produced to the left or to the right, just as different sorts of sugar rotate the plane of polarization of ordinary light to the right or to the left. Prof. Bose determined the index of refraction for his electric waves for different materials, and eliminated a difficulty which presented itself in Maxwell's theory as to the relation between the index of refraction of light and the dielectric constant of insulators. He measured also the wave lengths of various oscillations; to detect them and study their various properties, he had to construct a large number of new apparatus and instruments, and he has indeed enriched physics by a number of apparatus distinguished by simplicity, directness, and ingenuity. It was a hard task to produce very short electric waves which had enough energy to be detected, but Bose overcame this great difficulty by constructing radiators or oscillators of his own type, which emitted shortest waves with a sufficient amount of energy. As a receiver he used a sensitive metallic coherer, which in itself led to new and important discoveries. When electric waves fall on a loose contact between two pieces of metals, the resistance of the contact changes and a current passes through the contact indicating the existence of electric oscillations. Prof. Bose discovered the surprising fact that with potassium metal the resistance of the contact increases under the action of electric waves, and that this contact exhibits an automatic recovery. He found further that the change of the metallic contact resistance when acted on by electrical waves, is a function of the atomic weight. These phenomena led to a new theory of metallic coherers. Before these discoveries it was assumed that the particles of two metallic pieces in contact are, as it were, fused together, so that the resistance decreases. But the increasing resistance, appearing for some elements, leads to the theory that the electric forces in the waves produce a peculiar molecular action or a rearrangement of the molecules, which may either increase or decrease the contact resistance. Self-recovery and fatigue of these coherers reminds us of the phenomena of living organisms. Here we find indeed the natural bridge between the two fields of the scientific investigations of Prof. Bose, between physics and physiology.

With the advance of the various sciences it became more and more difficult for a single investigator to make contributions to different field of knowledge. The special theories and the methods of each science increase every year and the definitions of the concepts are so different that a scientific man rarely finds himself at home in a science outside his own field. Prof. Bose is one of the rare exceptions. As in physics, we find his investigations in the physiology of plants and animals clustered round one fundamental idea, the idea of the unity of all that lives. Again, as in physics, Prof. Bose made contributions to physiology by the construction of new instruments of investigations characterized by marvelous simplicity, ingenuity and sensitiveness. I will mention among a large variety one, the Resonant Recorder, in which the friction of the writing pen has been eliminated by means of the principle of resonance and which allows the measurement of time intervals as small as a thousandth part of a second. Bose also discovered a series of new phenomena and offered new interpretations.

In physics and chemistry the law of the uniformity of nature may be stated as follows:

Under the same conditions a given cause produces always the same effect.

In physiology Prof. Bose would probably express the same law in somewhat different terms as follows:

Under the same conditions a given stimulus produces in the plant and animal the same well defined response. Of course it is much more difficult to re-establish the same conditions in the living than in the non-living world. With increasing intensity of stimulus the response increases; at very high intensities of the stimulus, however, the response reaches a limit. Stimuli too small to produce a visible effect, if applied singly, become effective by superimposition. If the intensity of successive stimuli is kept constant it may still happen that the height of the corresponding responses gradually increases as if the molecules adapted themselves more and more to the external influences; this is the staircase effect, so well known in the cardiac muscle but also discovered by Bose in plants. Not only the intensity, but the frequency of stimulus affects the response. Fatigue and recovery play an important part in the response of plants to external influences, and these effects have been recorded by Prof. Bose's instruments with the same fidelity as purely physical phenomena. The influence of temperature, light drugs and poisons on vegetable and animal tissues have been studied and recorded. Plant and animal exhibit the same function of life on closer scientific investigation.

Let us illustrate this result by a few examples chosen at random from Prof. Bose's very rich scientific treasury. Let us ask, does the plant sleep? Is the plant equally sensitive to external stimuli during day and night? This problem was solved by new apparatus which delivers a questioning shock to the *Mimosa* plant every hour of the day and night, and which records automatically the response. The record obtained shows that the plant wakes up during the morning very slowly, becomes fully alert by noon, remaining so until evening, and becomes sleepy only after midnight, resembling the modern man in a surprising manner.

Electrical methods have been found more effective in the investigations of the functions of the plant than mechanical methods. Indeed mechanical movements in the plants are rather exceptional, while the animal enjoys the freedom of motion. There are even motions in the organs of animals like the beating of the heart, which seems to take place automatically, apparently without stimulus. These rhythmic automatic motions, these throbbings, however, occur in the plants also, for instance, in the oscillating leaflets of the telegraph plant. Temperature variations, anaesthetics, poisonous acids and bases have the same effects on the throbbing heart and the oscillating leaf. Moreover, in the plant-life it is possible to trace the evolution from simple to multiple and to automatic response.

A difficult problem arises in connection with the transmission of impulses through plant organs which resembles in many respects the transmission of excitation through nerves. The transmission of the impulse from the surrounding world follows the same laws in the body of the plant and of the animal.

There are other problems connected with the control of the nervous impulse at will, and with the existence of memory. The researches of Bose have proved that there is no physical property of matter exhibited in the living world which is not manifested also in the inorganic world. Indeed the investigations of Bose have shown not only a continuity of reactions between plants and animals but also the oneness of matter and its properties in the living creatures and in non-living matter. We admire the human eye as one of the finest products of the creative power of nature, yet Prof. Bose was able by purely chemical means and physical forces to discover a photo-electric cell, an artificial eye, which shows essentially the same relations between stimulus and response as the human eye. Incidentally, he discovered the surprising fact of a binocular alternation of vision in man.

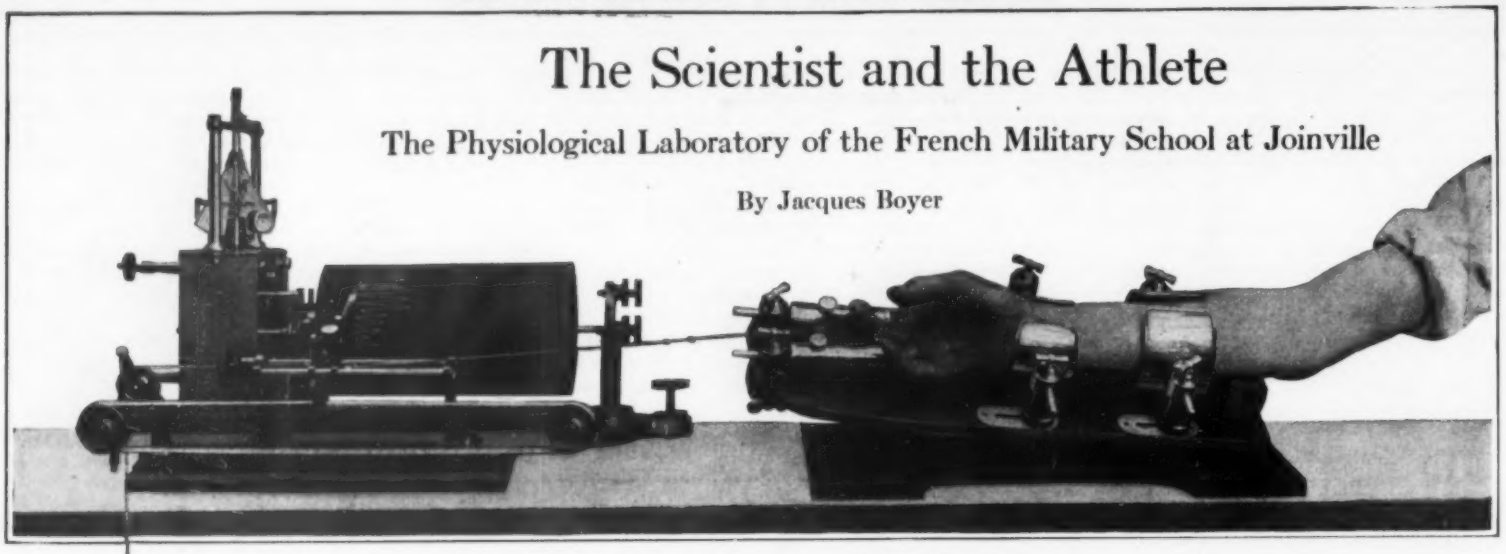
The uniformity of responses by animals, plants and metals are recorded by diagrams so identical that one could not tell which belongs to the animal kingdom or to the plant, or to the dead metal. The laws of nature hold uniformly throughout the whole material world. Thus Nature is a universe, a cosmos, whose secret laws the human mind is able to decipher.

Interesting accounts are to hand from Sweden regarding the results of trials lately conducted by a leading Swedish company on two sister steamers, one—the "Mjölner"—being fitted with turbo-electrical engines and the other—the "Mimer"—with ordinary triple-expansion engines. Each steamer is of 2,225 tons displacement and designed for a speed of 11 knots, a stipulation being that in each case the engines were to develop 900 indicated horse-power. The most important factor, however, was with regard to the consumption of coal, which was guaranteed to be 30 per cent less in the turbo-electrical vessel than in that fitted with the triple-expansion engines. For the trial trip, which lasted 7 hours, the screws of the "Mimer" were fitted to the "Mjölner," so as to avoid possible difference arising from any difference in construction. During the trip the turbo-electrical engine developed 975 indicated horse-power, or 75 more than the guaranteed maximum, while the average speed was 11.8 knots, as against 11 guaranteed. Good as these results are, the small consumption of coal exceeded the most sanguine expectations, amounting to 0.4 kilogramme per indicated horse-power, which works out at 35 per cent less than the consumption on the sister ship, the "Mimer." Both steamers are to be employed in the coast trade and their hulls have been especially constructed for navigation in the ice.

The Scientist and the Athlete

The Physiological Laboratory of the French Military School at Joinville

By Jacques Boyer



The Mosso ergograph, which registers the work done by the fingers.

At the normal fencing and gymnastic school which the French war ministry maintains at Joinville, systematic physical training is given to perfecting the exercises and officers and men, and methods of imparting it are investigated. Especial attention is given to the physical condition of the men of scientific researches carried on in the methods of training, with the aid of scientific laboratory of the school. In addition to the counting and recording instruments which are commonly employed by physiologists and psychologists for the study of respiration, circulation, and muscular contraction, the laboratory contains several novel and interesting instruments invented by Prof. G. Demeny for the determination of the form and dimensions of the body at rest and in movement. The laboratory is also well equipped for work in photography, including chrono-photography and kinematography.

The dimensions of the thoracic cavity are measured with calipers having blunt tips of ivory. One of these tips is affixed directly to one leg of the instrument, but the other tip is attached to a rod which can move in a graduated slide against the pressure of a spring. This construction allows the calipers to be withdrawn without opening them or wounding the subject. When the instrument is applied to the chest the spring tip remains in contact with the body without interfering with respiration, so that the travel of the rod measures the augmentation of the thoracic diameter in the act of inspiration. By connecting the rod with a pair of Marey capsules, a continuous record of the variations in diameter can be inscribed on a rotating cylinder.

In order to obtain more precise measurements of all dimensions of the body, Prof. Demeny has devised an instrument, the double universal conformator, which can be adjusted to trace on paper outlines of the median vertical section of the trunk, and of horizontal sections at various heights. The essential organ of this apparatus is a metal rod, to which numerous thin strips of wood, forming a continuous series, are attached transversely in such a manner that each strip can move independently in a direction parallel to its length (or at right angles to the rod) and that all the strips can be fixed in position by turning a nut at the end of the rod. The ends of all the wooden strips are brought into contact with the body, and the nut is screwed down. The contour of the body can be traced on paper from the profile of the strips thus immobilized.

With two such rods, mounted parallel to each other on suitable supports, the form of horizontal sections of the body, or of its lateral or anterior and posterior vertical profiles can be determined very quickly. Complete horizontal sections of the chest at various levels are obtained by attaching four rods to a rectangular frame, inside which the man stands on a platform which can be raised to any desired height.

The Demeny conformator reveals immediately and without calculation any defect of symmetry, such as unequal height of shoulders or hips, abnormal curvature of the spine, etc.

For the special study of the spine an instrument called a sachigraph or profilograph has been devised. Four rods, connected by movable joints to form a rhomb, are supported by a carriage that moves in a slot in a vertical post. The subject stands with his back to the post, and the carriage is moved upward, while a blunt point attached to one vertex of the rhomb is pressed against his spine. Simultaneously, a pencil attached to the opposite vertex of the rhomb traces the profile of the spine, in its true dimensions, on a sheet of paper.

Vertical sections are obtained also by an instrument which traces the profile on paper by means of pencils attached to two rods, mounted on rollers, between which the subject is placed, and which measure the thickness of the body at every point as they move up or down.

The volume of air introduced into the lungs by a deep inspiration is measured by a very simple spirometer. The inhaled air is expelled through a rubber tube into a cylindrical bell-glass, which dips into water contained in a larger glass vessel. The cross-section of the tube is made equal to that of the trachea in order to minimize resistance and disturbance of the rhythm of respiration. The bell-glass is suspended by a cord which passes over two pulleys and has a counterpoise attached to its other end. The bell-glass rises as the air is blown into it, and if its wall were infinitely thin its rise, indicated by the emergence of an attached scale from the water, would be exactly proportional to the volume of air introduced, the pressure remaining constant. In practice, however, there is a small increase of pressure, which is measured by a manometer inside the bell-glass and is applied as a correction. The spirometer is calibrated by injecting air in measured quantities, one liter at a time, and reading both the water level scale and the manometer after each addition.

Many of the physiological researches that are conducted in this military school are executed by Marey's method, which is capable of furnishing graphic records of respiratory movements, the pulsations of the heart and the arteries, muscular contractions, the pressure of the feet on the ground in walking, leaping, etc. The part of the body which is being examined is brought into contact with the flexible membrane of a Marey capsule, which is connected by a rubber tube to a similar capsule, whose membrane carries a stylus that presses on a cylinder covered with blackened paper and turned uniformly by clockwork.

The variations of muscular effort are registered by the well-known ergograph of Mosso.

The mechanism of bodily movements is studied also by means of photography, kinematography, and, especially, chrono-photography. The kinematographic analysis of movements enables the physical instructor to discover the physiological consequences of various exercises, and to classify the latter according to their effects, but he must control his deductions by attentive observation of the movements.

Chrono-photography may be defined as the photographic reproduction of successive positions of a moving object on a single fixed plate. Graphic chrono-photography is based on the same principle, but it furnishes a much larger number of images in a given time. The pictures of this sort that are produced at the Joinville school are exceedingly interesting, and convey very valuable information in regard to walking, high and broad jumping, and other exercises. So, at Joinville, physiologists and trainers work together for the improvement of physical education.

The Sterilization of Water-Supplies for Troops on Active Service*

By G. Sims Woodhead, M.D.

Some years ago, while working at the sterilization of the Cambridge water supply, I found that it was not necessary to make a bacteriological examination in order to determine whether the bacillus coli group had been killed by the addition of certain quantities of bleaching powder (chloride of lime) to the water under observation. Working with very dilute solutions of bleaching powder I found that the amount of "available" chlorine required to be added to the Cambridge water to "sterilize" it was frequently only about 1 part in 7,000,000. In such cases the number of bacteria present was very small and the amount of organic matter very low, and I found, even after the addition of the above small quantity, that if, a quarter of an hour after the addition of the chloride of lime, I obtained a blue or a violet-blue reaction with iodide of potassium and starch, as much as a liter and a half or even two liters of the treated water did not contain a single "living" bacillus coli communis. In some earlier experiments I was able to demonstrate that the typhoid and cholera bacilli were perhaps even less resistant to the action of hypochlorous acid than was the bacillus coli communis.

Carrying out a further series of experiments, I satisfied myself that if the particulate matter could be removed from a water by means of any of the ordinary filters it was possible to render even a highly polluted water perfectly safe for drinking purposes by the addition of appropriate amounts of chlorine, and that these appropriate amounts could be determined by means of the iodine and starch test.

The following is a method of testing and sterilizing water for the information of those in charge of the water-cart tanks supplying troops on active service.

All water except that from public tap-water (potable) supplies must be regarded as dangerous and unfit for drinking.

Filter through the best rough filter available, e. g., army service filter, improvised sand filter, etc.

Pollution in water may be detected and the water rendered safe for drinking by the following method:

TEST BEFORE TREATMENT IN BULK.

Instructions I.—Rinse a clean enameled iron or earthenware pint mug with the water to be tested, leaving a few drops in the vessel. Add 2 grammes of bleaching powder (chloride of lime, chloro-hypochlorite of lime) and make into a thin paste, rubbing it down with a clean stylographic pen, penholder, pencil, or glass or other similar clean rod available. Then add 500 cubic centimeters or 18 ounces of water (i. e., fill to within $\frac{3}{4}$ inch of the lip of the enameled mug or $\frac{5}{8}$ inch of the lip of an earthenware mug) and mix thoroughly by pouring into a second mug and then back into 1. The quantities indicated below of the resulting solution may be used for testing purposes; the remainder is used for sterilizing the water. This solution should contain 0.66 gramme of available chlorine.

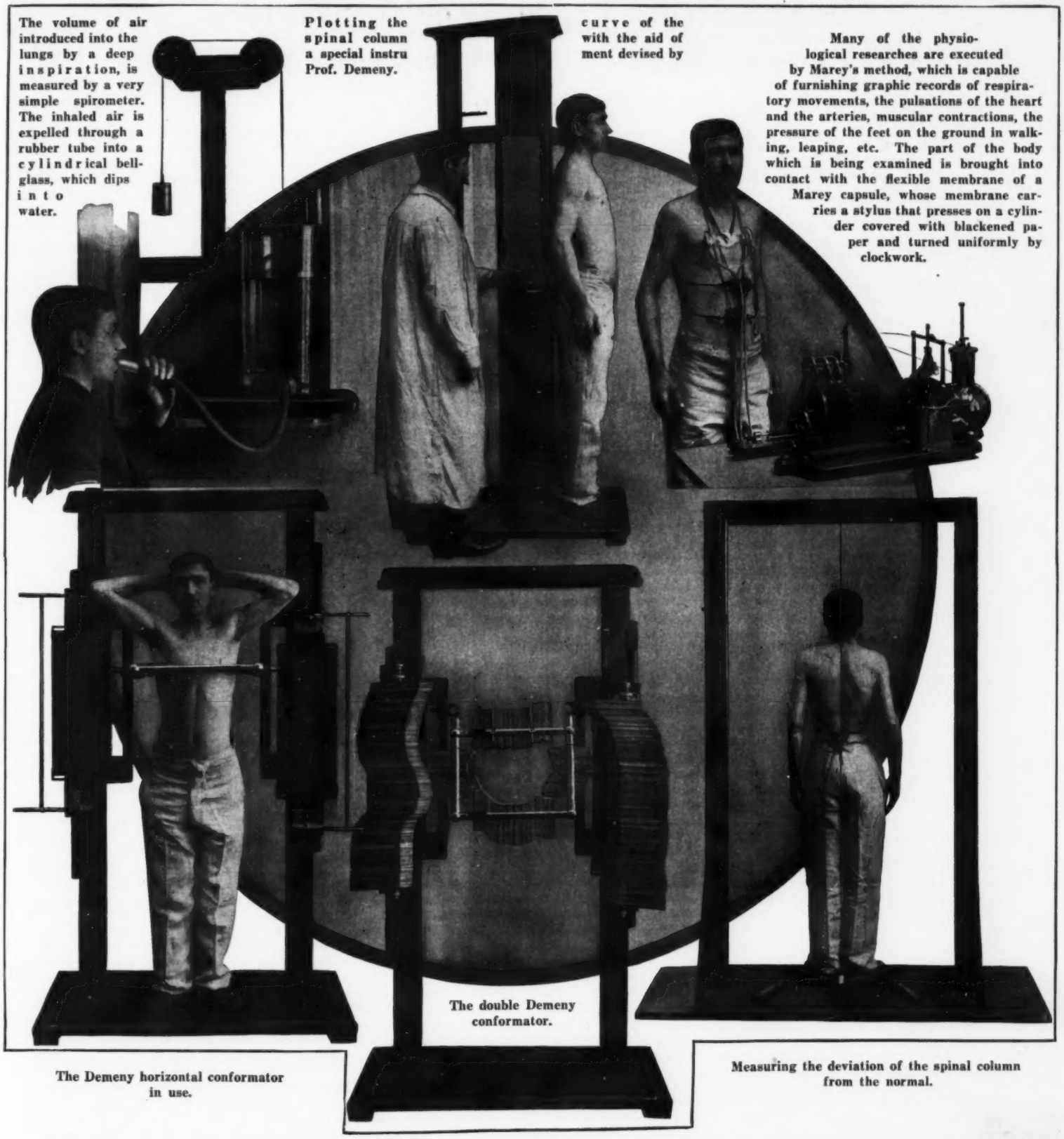
Instructions II.—Now fill four pint mugs to within $\frac{1}{4}$ inch of the top with the water to be tested. Then allow the bleaching powder solution to rise in a pipette graduated to contain 0.15 cubic centimeter to the mark; wipe the outside of the pipette and blow the contents into one of the four mugs of water to be tested. Add two similar charges of the pipette to a second of these mugs, three charges to a third, and four charges to a fourth, in each case mixing thoroughly (as under Instructions I), and allow to stand for 15 minutes. Then into another clean mug crumble a small tablet of iodide of potassium; also after powdering, in the corner of an envelope or between a couple of layers of clean paper, a tablet of soluble or boiled starch, and pour into it the water from 3, and mix by pouring backward and forward from one vessel to the other. Add iodide of potassium and starch to cups 4, 5, and 6, treating in the same way. When a blue color appears in any of these mixtures it is an indication that the chlorine has not all been used up in that mixture; what remains sets iodine free from the iodide of potassium, which acting on the starch gives a blue color, i. e., more available

* From the *Lancet*.

The volume of air introduced into the lungs by a deep inspiration, is measured by a very simple spirometer. The inhaled air is expelled through a rubber tube into a cylindrical bell-glass, which dips into water.

Plotting the curve of the spinal column with the aid of a special instrument devised by Prof. Demeny.

Many of the physiological researches are executed by Marey's method, which is capable of furnishing graphic records of respiratory movements, the pulsations of the heart and the arteries, muscular contractions, the pressure of the feet on the ground in walking, leaping, etc. The part of the body which is being examined is brought into contact with the flexible membrane of a Marey capsule, whose membrane carries a stylus that presses on a cylinder covered with blackened paper and turned uniformly by clockwork.



The double Demeny conformator.

The Demeny horizontal conformator in use.

Measuring the deviation of the spinal column from the normal.

chlorine than was necessary to carry oxygen to the organic matter and less resistant organisms has been added, and the water treated in bulk as under Instructions III, is rendered "safe." To free the water from the bacillus coli communis and from non-spore-bearing pathogenetic water-borne organisms it is not necessary to add more bleaching powder than is indicated as required by the test.

Instructions III: Sterilization of the Water.—Should No. 3 give a blue, violet, or brown color (best seen by daylight) the contents of cup 1 may be divided into two equal parts, each of which is sufficient to sterilize 110-120 gallons of water. Distribute this amount, pouring equal quantities into each of the four divisions of the service tank when it is about half filled, and when filled allow to stand for 20 minutes. The water may then be used for drinking without filtration or further treatment. Should No. 3 give no color, but No. 4 become blue, add the whole of the contents of No. 1 to 110-120 gallons, distributing in the same way and rinsing the mug several times so as to wash into the tank the whole of the bleaching powder. Should No. 4 give no color, but No. 5 become blue, dissolve a second sterilizing powder "A" (2 grammes of bleaching powder) and add half of it along with the contents of No. 1 to the 110-120 gallon tank. Should No. 5 give no color, but No. 6 become blue, add the whole of the contents of the two tubes "A" to 110-120 gallons. In each case allow the water to stand for 20 minutes before issuing it for drinking. Should No. 6 give no color the water should be regarded as highly polluted, and as palatability is a matter of some importance it should be boiled. By the addition of more bleaching powder, however, up to 6 or 8 grammes per 110-120 gallons it may be rendered innocuous, though in some such cases it may be less palatable.

N. B. (1) The great advantage of this method is that it is not necessary to await the result of a bacteriological examination. The amount of bleaching powder required to render the water safe for drinking purposes may be determined in 20 minutes. Where a new or a variable water has to be used, this is a matter of prime importance.

(2) Other advantages are that with the exception of the pipette no special apparatus is required, and that as the same solution is used for both testing and sterilizing any fall in the available chlorine content of the sterilizing powder is equalized by a similar fall in the test solution, and the need for the addition of more sterilizing powder at once indicated.

(3) If for any reason the supply of standard sterilizing tubes should fail it will be found that three times as much fresh, clean, dry, loose bleaching powder (which should contain 33 per cent of available chlorine) as can be lifted on a sixpenny piece grasped between the thumb nail and the tip of the first finger and used as a spoon weighs 2 grammes and corresponds to the amount contained in one of the standard sterilizing tubes.

(4) A rough test of the condition of the water to which bleaching powder has been added may be made by taking a cupful of water from the tank 15 minutes after the addition of the sterilizing powder, dissolving in it one each of the tablets "B" and "C" (starch and KI) and mixing thoroughly. Should no color appear add another charge to the tank, and again apply the rough test.

(5) A treated water to be "safe" should, at the end of 15 minutes, always give a blue "reaction" on the addition of the tablets "B" and "C."

This method may also be used for the testing and sterilization of the water-supplies of small communities.

Gas and Steam Engines and the Turbine*

Cost of Operation, Investment and Depreciation at Blast Furnaces and Steel Works

By J. E. Johnson, Jr.

UNTIL within a few years only one type of prime mover was used at blast furnaces, steel works and rolling mills—the steam engine, but within that time the steam turbine and the gas engine have forged ahead at a tremendous pace. For a while they threatened the steam engine with extinction, as the turbine could get along with half and the gas engine with a third of the heat consumption required for fairly good engines a few years ago. There is no doubt that the steam practice at steel works and blast furnaces, particularly the latter, a few years ago was almost as bad as could be. In spite of the fact that 10 per cent of the gas is sufficient to blow the furnace with good practice, the whole 50 per cent not used by stoves and auxiliaries was frequently insufficient and coal had to be burnt under the boilers to help out. This condition persists even yet at many plants.

This was the condition with which the gas engine and turbine builders made comparisons and of course the showing was a bad one for the old steam engine. After a while the steam engine builders and the operators of the plants began to see that there were great possibilities in the use of that prime mover which they had neglected. One of the conditions indispensable for best economy with the turbine is superheat. This has long been known as very beneficial to the steam engine, still no one took the trouble to develop the practice for that purpose. But after it had been developed for the turbine it was applied in earnest to the steam engine. The same thing applied to condensing practice in a less degree. The turbine is simply lost without high vacua, far higher than had ever been considered for the steam engine, and new types of condensers were developed for it, but this development showed up in high relief the absurdity of running reciprocating engines non-condensing, and the improved condensers were applied to them, with the result that no large engine plant built with regard for economy is now ever designed to run non-condensing though that practice was standard in the iron and steel business twenty years ago.

With these improvements have gone a rapid increase in boiler pressure and a general overhauling of designs, so that large steam engines can still compete on the heat economy basis with turbines of equal size. On the other hand what is large for an engine is rapidly coming to be small for a turbine. The largest power engines ever built were double compound horizontal-verticals with four cylinders which were of 8,000 horsepower each. There were five of these in one station. A few months ago a single steam turbine was installed in that station, started up and put into the line. Then one after the other the five engines were shut down and the load of each in turn thrown on the turbine.

In electric power development the turbine has three vast advantages over the steam engine, which for large powers have enabled it to outclass the latter utterly, so that the steam engine is no longer considered for such service. The first is that the pressure of steam is converted directly into rotary motion immediately available for driving generators, whereas in the steam engine the pressure must first be converted into a reciprocating motion and that transformed through an expensive mechanism into rotary. In the second place the refinement of the engine has led to increasing complexity, and many moving parts with various motions, whereas the turbine has in effect a single moving part with the simplest possible motion, a uniform speed of rotation. This vastly reduces the supervision and upkeep of the latter as compared with the former. Third, the speed of rotation of the engine is limited by the motion of the parts to about 100 revolutions per minute in large sizes, which necessitate large and very expensive generators for direct connection to it, whereas the speed of the turbine is from 1,000 to 3,000 revolutions per minute and the corresponding generators are very much cheaper.

When we come to blowing engines, we find the relative positions of these two motors to some extent reversed. There are two systems for compressing air, the time honored one with cylinder, piston and valves which operates by direct pressure, and the multiple fan system of imparting a tremendous velocity to the air by a rapidly revolving runner and transforming this velocity into pressure by driving it through a converging nozzle. The velocity and pressure which we can obtain at one operation are limited, but by putting several such fans in series we can obtain any pressure we wish. The operation is the exact opposite of that of the turbine with the difference that where the conversion of pressure into velocity on which the turbine operates can be carried on with very high efficiency (above 95 per cent), the converse operation of converting velocity into pressure can only be carried on with an efficiency of about 70 per cent.

On the other hand, the over-all efficiency of the direct connected reciprocating blowing engine is extremely high—between 85 and 90 per cent in good practice—so that the best designed reciprocating steam blowers under the same conditions as the turbine driven blower have a considerable advantage over the latter in steam consumption. On the other hand, the steam engine costs a little more to install than the turbo-blower, against which we may set the fact that owing to its lower steam consumption it requires less expenditure for boilers.

Great advantages are claimed for the turbo-blower for its smooth and non-pulsating discharge; on the other hand, this is claimed by others to be a positive disadvantage. The metering action of the positive piston compressor is believed by many to be a very great advantage, while on the other hand this action is claimed by the advocates of the turbo-blower not to be nearly as accurate as the volume control of their machine. You will see, therefore, that this is an extremely live question at the present time, and in some company it is scarcely safe to make a positive statement on either side without first putting on a suit of armor.

For driving rolling mills the conditions are different from either of the others. The largest mills handling the huge ingots in their original shape are known as "blooming mills" and these, for reasons for which we need not stop to consider here, generally have to run in both directions to drive the piece back and forth through the rolls; and as these mills are geared directly to the engine it must be of the reversing type. Here the steam engine takes the first position, with no second, since it is the only prime mover which can be reversed at all, let alone at intervals of literally a second or two.

Some of these engines are triumphs of the engine builder's art and are among the most powerful built, having two pairs of tandem cylinders 46 inches and 76 inches in diameter by 60-inch stroke, running condensing with a steam pressure of 150 pounds and up to 175 revolutions. These are reversed from full speed in one direction to full speed in another in three or four seconds, in spite of the vast weight of their reciprocating parts. The shocks are such as no machine should be called on to stand, but they do it and so far no way has been developed to meet some conditions as well as this type of mill and engine, though I have hopes. For non-reversing mills direct geared turbines and gas engines have occasionally been applied, but in the vast majority of cases steam engines are used or else electric motors.

The double transformation of energy involved in the electric drive is expensive in fuel cost and what is much more important it is very expensive in first cost, and it is rather surprising that more has not been done in the designing of non-reversing mills direct geared to the gas engine, and especially to the steam turbine, since the latter has a high efficiency through a wide range of loads, or, as we say, a flat steam consumption curve, which is very important in highly intermittent work like that of rolling mills. I believe that a considerable development will take place in this field in the not distant future.

This motor, as you well know, works on a totally different principle from either of the others and has consequently very different characteristics. It is not capable of much change in speed and its economy drops very rapidly as the load falls off, largely because the friction of the engine is very high and is almost constant, irrespective of the load, so that a friction of 20 per cent at full load means one of 40 per cent at half load, and so on.

This type of engine is also capable of carrying only very slight overloads; that is to say, its most economical load is its maximum load, and any overload capacity is secured only at the expense of economy and at the price of buying a larger engine. In these respects it is at a great disadvantage as compared with either the steam engine or the turbine, both of which have a large overload capacity which extends far beyond their most economical load. On the other hand, the gas engine cuts out entirely the boiler, and above all it has a heat consumption only about two-thirds or three fourths of that of the best steam plants.

It was at one time supposed that this fact was destined to make the gas engine the preferred prime mover for all electric power work; but other considerations came in and this expectation has not been realized, and some of the best gas engine men admit that where coal is the fuel used its day of realization has been indefinitely deferred.

Leaving out of consideration altogether the question of first cost and capital charges for the present, let us consider only the operation. Before coal can be used for gas engines it must be gasified in a gas producer, an apparatus having an efficiency when delivering cold gas (which a gas engine must have) of 75 to 80 per cent, which is almost the same as that of a well designed and operated boiler plant. On that basis the two are even; but while coal may be burnt under boilers for a few cents a ton, say 15 cents, in large plants, it cannot be gasified for much less than 45 cents and often 50 cents.

Now, the efficiencies of the producer and the boiler being almost the same, the fuel consumed will be in the same rate as the heat consumption of the two motors themselves; say, as a liberal figure, 14,000 British thermal units for the turbine and 12,300 for the gas engine, a ratio of 1.17 to 1. Then if the coal cost $1 delivered, its cost burnt under boilers is $1.15 and gasified $1.45. The fuel cost is proportional; therefore it is $1.15 \times 1.17 = $1.34 for the steam turbine and $1.45 for the gas engine. That is, the heat units used by the gas engine are less, but the money cost of fuel is more.

This is all based on full load conditions; and while the cost for both goes up very rapidly for lighter loads, owing to the flatter heat consumption curve of the turbine and its small relative size owing to its much greater overload capacity, its heat consumption rises much more slowly, and as to the use factor in public service work is about 30 to 40 per cent it will be perfectly obvious that the advantage of the turbine over the gas engine will be much greater in the average than it is at maximum load, even in the heat unit basis. Of course, as the cost of coal rises the case becomes more favorable for the gas engine at full load, but it is very doubtful if under any ordinary commercial conditions its practical economy in the average is much higher than that of the turbine.

When we come to the iron industry we come to a different condition, very much more favorable to the gas engine. This is that the fuel to be used is already gasified by the blast furnace, this gas being in fact almost an ideal fuel for gas engines, and they are therefore entirely freed from any change or loss of heat for gasification, except that the sensible heat of the gas, 6 to 8 per cent in good practice, must be sacrificed to fit the gas for gas engine use.

The steam plant on the other hand is under the necessity of burning this gas under boilers with the same losses as occur in coal firing, except that the labor cost is very small. In the past the economy of furnace boilers has been extremely poor. I have tested boilers where it was down to 30 per cent and 50 per cent was about average practice until quite recently; but just at the present time this subject is receiving great attention and boilers are being operated at an efficiency of 75 to 80 per cent in regular work. In this case the full-load fuel consumptions are propoptional to $\frac{77}{1.77} = 0.66$ and $1.00 - 0.07 = 0.93$, or 1 to 1.41, with the further advantage that the gas engine is enabled to dispense with one whole operation and its attendant bother—the gasification of the coal. Moreover, the gas engine has in this service a further great advantage. The use factor is about 60 per cent for electric service in the steel industry, while for blowing engines it is nearly 80 per cent.

Why, then, are these engines not in universal use in such plants? Here we come to the real milk in the cocoanut. We have hitherto said nothing of comparative labor costs and of capital charges. In regard to the former the gas engine has had a bad name. The stresses which it undergoes are tremendous and breakdowns in the past were frequent and serious, while the uncertainty of the engine going at all was a decided factor in its early days. But if you remember the

* From an address on "Modern Power Plants in the Iron Industry," delivered before the Engineering Association of the State College of Pennsylvania. Republished from *The Iron Age*.

prayerful uncertainty with which a man started out on an automobile trip ten or twelve years ago, not knowing when or how he would return, and consider our present entire disregard of this as an important factor, you will admit that many of the defects of that type of motor have been removed and that its reliability now fairly challenges that of the steam engine—a condition which is rapidly becoming, if it has not already become, true of the larger types which we are considering. Nevertheless, the number of parts and variety of their movements is vastly greater in this engine than in the turbine, and the cost of supervision and operation is correspondingly greater. But leaving this question for a few minutes let us turn to that of capital charges.

These are made up of straight interest and an additional percentage on the investment which is set aside and saved at compound interest, so that at the end of the reasonable life of the plant we may have a sum in the bank equal to the original investment, with which we can either pay off the investor or buy a new plant. Any operation which figures its costs on any other basis will probably go broke, and certainly ought to. Five per cent at compound interest will equal the principal in about 14 years, which is about all the life we have a right to expect from a power plant. If it is not worn out in that time, it has most likely been designed off the map; that is, later improvements will have made it commercially undesirable to operate any longer, even though it be not nearly worn out.

This 5 per cent added to 7 per cent of the interest rate which must be figured on industrial plants, gives us 12 per cent capital charges over and above all operating costs of every kind. This is a minimum figure for plants of this kind. Make no mistake. These are not bookkeeping figures, and the shores of commercial history are covered with the wrecks of plants which failed to provide for these charges. No sensible business man will put money into a property which cannot figure on this basis and still show a profit.

We see, then, that the annual cost of power is made up of fuel, labor and one eighth of the cost of the plant. Let me illustrate this: I know of a plant where a furnace is blown with two gas blowing engines which cost $107,000 apiece, and which with foundation, house, crane and gas cleaning apparatus and connections erected complete, did not cost less than $275,000. They develop together about 2,500 horse-power, or a cost of $110 per horse-power installed. Coal of 14,000 British thermal units in this region costs about $1 at the plant. Steam engines of the best type, with their boilers and all accessories complete could have been installed for $55 per horse-power. These engines would have required certainly not to exceed 18,000 British thermal units per horse-power hour, delivered to the boiler, while the gas engines may get along on 12,000. Counting 8,780 hours per year, the loss per year is $6{,}000 \times 8{,}780 = 52{,}680{,}000$ British thermal units. That is a tremendous amount of British thermal units, isn't it? But how much money is it? One ton of coal cost fired, say, $1.15 and contains $2{,}240 \times 14{,}000 = 31{,}360{,}000$ British thermal units. In other words it would require 1⅔ tons of coal per horse-power year to make up the steam plant's deficiencies, or say $2 worth.

The difference in fixed charges, on the other hand, are 12 per cent of $(110 - 55) = \$6.60$, or a net loss of $4.60 per horse-power year by the use of the gas engine with 100 per cent use factor. On the other hand, gas blowing engines are now being built which can be installed for $75 per horse-power, and if these were used in a region where coal cost $2.50 per ton, the cost of make-up coal would be $4.20, and the fixed charges in increased investment would be $12\ (75 - 55) = \$2.40$, or a difference of $1.80 in favor of the gas engine under these conditions. This is 9 per cent on the additional capital required for the gas engine and might be considered a paying, though by no means a startling investment. For, owing to the uncertainties of industrial earnings, investors are not commonly interested in them unless they can see a manufacturing profit of about 15 per cent, and it is obvious that any additional expenditure required should show this amount or over, to be justified. In this case the amount is 7 per cent interest and 9 per cent net saving, or 16 per cent in all. It is right in this range of conditions that it begins to be good business to install gas blowing engines, though some authorities would insist that at least 2 to 3 per cent larger capital charges should be assessed against the gas engine on account of its high rate of physical depreciation.

Turning now to the generation of electric power, we find the conditions different again, because we have in the steam side the turbine with the direct rotary movement and its great capacity, while on the other we have the relatively slow speed of the gas engine and the consequent high cost of its generator with probably greater friction and less efficiency than when connected to a blower.

For these conditions we may take costs of $70 and $50, respectively, per kilowatt installed, and heat consumption per horse-power of $12{,}500 \div 90 = 13{,}300$ British thermal units per horse-power for the gas engine, and

$$\frac{12{,}500 \times 0.96}{77} = 15{,}600$$

per horse-power for the turbine, or 17,700 and 21,750 per kilowatt horse-power, respectively. The use factor is much lower in electric service than it is in blowing engine service. If we take 60 per cent we shall be liberal. This means that on account of peak loads, for which it is necessary to provide, the plant in the course of a year will only put out 60 per cent of its maximum rated power. This factor varies very much in different works, but is higher in all of them than in public service plants. The heat consumptions are about what may be expected under such conditions of loading, and are not altered by this condition, and neither are the costs, but the relations of these two are profoundly altered. The excess thermal units per kilowatt year at full rated capacity for the turbine above those for the gas engine are $8{,}780 \times (21{,}750 - 17{,}300) = 39{,}071{,}000$; and the coal to supply this at 31,000,000 British thermal units per ton is 1.26 tons at $2.50 per ton. This is worth $3.15, but the use factor is only 60 per cent, so only 60 per cent as much coal is required for make-up, and the value drops to $1.90, while the fixed charges are $12 \times (70 - 50) = \$2.40$. In other words, in such a case the saving in coal would not pay all the capital charges on the increased investment, which therefore would be a bad one. Moreover, while the cost of labor and supervision for gas blowers may be no greater than that for steam engines and boilers together, undoubtedly their cost for gas-driven generators is greater than it is for steam turbines and boilers, and this increased cost would further throw the scale against the gas engine. But as the cost of coal rises conditions are reached under which the gas engine pays, while as its first cost falls the fixed charges fall also and tend to make its employment sound from the business point of view.

You will see now, I think,, why John Doe in Tyrone, where coal is cheap, may be a fool to do what has paid Richard Roe well in Boston, where coal is dear, and the engine that is the most economical of coal may be far the most wasteful of dollars. A recognition of this must be at the basis of all sound engineering and the fact that it is not always realized by engineers has done more to deprive them of the standing in the business which they should have than any other one thing.

Salt and Its Relation to Nutrition*

Common salt is a commodity, the annual production of which is known to exceed 12,000,000 tons. Of this huge total a large share is used as a preservative or otherwise employed in industry, yet an immense quantity is deliberately added to the diet of mankind. It is said that an individual consumption of 20 grammes a day is not unusual. This average, sustained for a year, would amount to about 17 pounds. The ration appears surprisingly large when we observe that it may be as much as one quarter of the total weight of protein taken and equal to one twelfth of the combined starch and sugar which constitute our main dependence for running the human engine.

It is agreed by all writers on the subject of nutrition that only a small part of this salt consumption is necessary. The rest is dictated by appetite; it is due to the common liking for the salty flavor. Individuals are found who do not care for this and who are said to eat no salt. This means that they use none voluntarily at table and perhaps direct that none shall be used in the kitchen. Yet they continue to receive a small salt ration because some is present in most foods and there is reason to believe that this minimal supply cannot be dispensed with. Sodium chloride is the chief salt in the blood and in the other fluids of the body. It is accordingly plain that growth cannot be continued unless this compound is furnished along with the other necessary nutrients.

When full stature is reached the need for salt is doubtless diminished. It might cease entirely if it were possible to avoid all loss of salt in the excretions. This possibility is nearly but not quite realized. When a man fasts for several days the escape of sodium chloride from his system sinks to a low level but remains appreciable. It may be in the vicinity of 0.6 gramme in the 24 hours. In complete starvation this gradual loss is probably not out of proportion to the general reduction of weight. Hence it does not lead to an actual lowering of the percentage of salt in the body. A diet sufficient in all other respects, but lacking salt, might bring to pass such a lowering.

One interesting result of using a salt-free diet has been observed in the failure of the glands of the stomach to produce hydrochloric acid. This valuable aid to digestion and antagonist of putrefaction must be evolved from the chlorides of the blood. Apparently it is not secreted when the concentration of these substances in the blood is at all below the normal and this in spite of the fact that the chlorine ions of the gastric juice can probably be recovered quite successfully. The suggestion has been made that restriction of salt should be beneficial in cases where gastric acidity is excessive.

Bunge, an Austrian physiologist, has collected a great volume of data concerning the habits of different races as to the use of salt. It is evident that some people set a high value upon it while others do not care for it at all. Where it is prized it has often figured in maxims and metaphors. "To earn one's salt" is a familiar phrase which gains point from the common origin of the words "salt" and "salary." Bunge learned that a certain East Indian tribe used as the most solemn oath in their court procedure the formula, "May I never taste salt again if I speak not the truth."

A little investigation shows that the desire to add salt to the food is experienced most by those who are vegetarians or nearly so. Men who are strictly carnivorous abhor salt. Thus it was found by the agents of the Russian government that the natives of Kamchatka could not be prevailed upon to salt the fish which formed their entire diet. The supply of fish was uncertain and that which was saved to eat in the long intervals between catches decomposed in shallow pits. Still it was preferred to salt fish. We notice the same detestation of salt among carnivorous animals.

The Arctic explorer Stefansson has recently reported a striking instance of the objection to salt which accompanies the use of a flesh diet. The Eskimo, whom he knows so well, have little vegetable food. When he settled among them he was embarrassed by their demands upon his hospitality. Policy dictated that he offer them food on all occasions but there was every prospect that his stores would be rapidly depleted. The situation was relieved by a simple device. It was only necessary to salt the food moderately—merely to his own liking—to deter his visitors from making inroads upon it. The requirements of courtesy were satisfied and the provisions were conserved.

When a sample of food is burned as completely as possible the mineral constituents remain as ash. Chemical analysis of this ash leads to very different findings in the case of different foods. Several acids and bases will always be found. We will consider only the occurrence of sodium and potassium. The ratio between the quantities of these two bases is widely varied, though in the great majority of instances potassium is the more abundant. In animal foods the disparity is not marked but in most vegetable substances it is striking. For example, the proportion of potassium to sodium in meat (veal) is 4 to 1, while in potato it is more than 30 to 1.

Can we recognize a causal connection between the excess of potassium in a vegetable diet and the craving for sodium chloride which is attendant on the use of such a diet? Bunge maintains that we can. His explanation has been criticised in detail but is probably valid in its main thesis. The absorption into the blood of a quantity of salts, unlike those normally present there, imposes upon the kidneys the duty of restoring standard conditions. If the chief demand is for the removal of potassium compounds the task will soon be accomplished. But this will not be done without a considerable loss of sodium chloride. It would be remarkable, indeed, if the kidney cells could select all the foreign ions and not occasionally let slip some of the much more numerous native ones.

Bunge was able to demonstrate, upon himself, the fact that an excessive intake of potassium salts does lead to a loss of sodium chloride. He swallowed as much potassium phosphate and citrate as he could tolerate and subsequently excreted all the potassium—equivalent to 18 grammes K_2O—but simultaneously eliminated 6 grammes of sodium chloride. Such a draft upon the tissues could not be continued indefinitely unless salt were supplied in corresponding amount. Bunge's personal experiment was not an unreasonable one, for it is calculated that when potatoes form the bulk of a man's ration twice as much potassium may be ingested as in this trial.

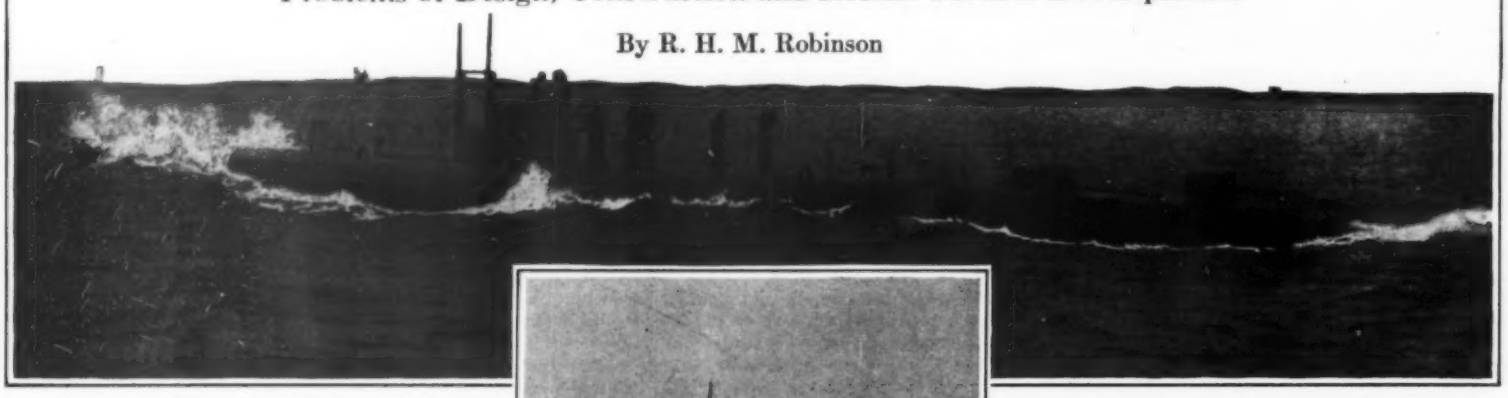
There is, therefore, no doubt that salt is a necessary addition to diets in which the ratio of potassium to sodium is unusually high. The instinctive craving for it is a marvelous instance of the almost infallible correctness of such impulses. Bunge has recorded the use by an African tribe of the ash of a certain tree as a seasoning for their food. Most kinds of wood reduced to ashes would yield a mixture over rich in potassium which would be a most undesirable adjunct to other articles of vegetable origin. But the tree in favor with these people was the rare exception; its ash contained a most unusual proportion of sodium compounds. It is rather painful to fancy the tedious succession of experiments by which the ancestors of this tribe eliminated various kinds of wood, and pleasant to imagine the satisfaction realized when the fortunate choice was finally made.

*By Percy G. Stiles in *Science Conspectus*.

The Submarine in Naval Warfare—I*

Problems of Design, Construction and Recent Tactical Developments

By R. H. M. Robinson



The United States submarine "G-2" running full speed at the surface.

Driving into a choppy sea.

WHEN I accepted the Institute's invitation to address you, war had not been declared, but since its declaration the history of the submarine in warfare has been in the making, and so much has happened and was likely to happen, bearing on my subject, that I postponed preparing any paper until the last minute, and so, I fear, should apologize for it.

As an actual designer and builder of submarines I am fairly new at the game, though I have to draw on the accumulated experience and advice of my colleague, Mr. Simon Lake, one of the pioneers in the practical submarine field.

Most of my early experience in the field of design and construction was with surface warships, with which I may claim reasonable familiarity, having, during an eight years' tour of duty as assistant to the chief constructor of the navy, supervised the design of every dreadnought now in commission in our service and half of those now building, together with numerous other surface craft of all types.

It is, therefore, on my knowledge of the vulnerability of the dreadnought type to submarine attack as much as on my knowledge of submarines that I must base my right to talk to you.

In the beginning permit me to say that I am not one of those who believe the submarine a cure for all naval ills, or that it will supplant surface warships.

I am, however, and have always been, a strong advocate of the submarine as one of the most powerful naval weapons of defence, and as possessing offensive qualities which, in the fulness of time and with the development of engineering science, cannot be minimized.

The wording of my subject might imply that I expected to pose as a prophet, but I should prefer, if I may, to show you certain facts and in most instances to allow you to make your own prophecy.

Admiral Sir Percy Scott, of the Royal Navy, in his now famous letter to the *London Times* of June 5th, last year, took the strongest possible stand for the submarines and, incidentally, against the battleships, concluding his letter with the statement: "In my opinion, as the motor vehicle has driven the horse from the road, so has the submarine driven the battleship from the sea."

Coming as it did from one who had contributed so much to the development of the battleship offensive power, this letter made an enormous impression, though I cannot but believe that Admiral Scott stated the case somewhat more strongly than was justified or than he himself really believed.

What may very well be the case is that the effect of the submarine will be to reduce the rapid growth in size and expense of the dreadnought type, now reaching to almost unbearable amounts.

The menace of the submarine arises, first from her invisibility, and, second, from the fact of the difficulty of providing against the damage which will result from a blow from the weapon she carries.

Sir John Biles, LL.D., in a recent paper before the British Institute of Naval Architects, says:

"There can be only two forms of defence: first, the destruction of the submarine by other vessels, submarines or others; second, the protection of the bottom of the surface ships from the effect of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ships until it is destroyed, and, as the means of destruction are not yet certainly at hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless some one is ready with a real reply to the submarine."

A great deal of attention has been given by naval architects to providing, in the dreadnoughts, protection against the automobile torpedo, with astonishingly small success up to the present time.

I personally struggled with this question for a good many years, and I believe, without conceit, that the United States has to-day as good a solution as has yet been obtained, but even that is by no means perfect.

For a ship at anchor a reasonable protection against the possibility of damage from the automobile torpedo may be obtained by the use of torpedo nets, although the development of the net cutter, attached to the torpedo's nose, has made even this uncertain. It is almost impossible to use a torpedo net on a ship under way. In the first place, it enormously decreases the speed and handiness and enormously increases the fuel consumption of the vessel wearing the net, and, in the second place, the mere fact that the vessel is under way causes the bottom of the net to rise to the surface and thereby largely does away with the advantage of the net.

This being the case, the only remaining possibility is to include within the structure of the vessel itself provision against damage by attack from a torpedo. Unfortunately, it is much easier to increase the power of the torpedo than it is to increase the defensive protection built into the hull of the dreadnought, with the result that, if any given class of surface ship has protection against the then existing torpedo, it is fairly easy to vitiate the value of this protection by increasing the power of the torpedo.

Briefly, the provisions which may be embodied in the design of a ship against the damage of the torpedo comprise under-water armor, additional compartmenting, and compressed-air installation for localizing the inflow of water. The under-water armor, on the face of it, looks like a good solution of the problem, but, as a matter of fact, it is of very little use to put under-water armor on the external hull of the ship. A torpedo explosion has a crushing effect, which results in tearing the riveted joints. The rivets seem to be attacked in detail, and an increase in the amount of metal applied externally does not do away with the necessity for riveted joints, and, if under-water armor were put on the ship in the same manner as the above-water armor, there would be *no* connection at the joints, since the armor above water is simply plastered up against a backing plate.

Careful and minute compartmenting, of course, covers a large number of possibilities, but provides only against the damage done by the torpedo in localizing the effect of the damage.

The compressed-air installation is a means of preventing water entering the body of the ship in too large volumes as the result of any damage done by a torpedo. It has to be specially applied, utilizing what is called the "backing up" method, using pressure in the adjacent compartments of varying degrees so as not to damage the ship's structure by the air-pressure.

The best solution of the problem is a combination of the three methods referred to above:

Proper compartmenting—and by this I mean something different from the time-honored system in use in the older days—under-water armor not located on the external hull of the ship and so designed as to give a maximum strength to the structure of the ship, and a graduated compressed-air installation for checking the water after it gets into certain compartments which cannot be prevented.

There are several essential features in designing a surface ship and in providing these anti-torpedo protective features which must be looked out for. The principal among these is the effect on the longitudinal or transverse trim of the vessel, from water getting into one or more compartments. The question of longitudinal trim is ordinarily not as important as transverse, and provision may be made, and has been made, for balancing transverse trim or list by admitting a similar amount of water on the opposite side to that damaged. This course results in a greater sinkage and consequent reduction in speed and safety of the vessel, but, when a balancing system is properly arranged in combination with the defensive means mentioned above, it should probably result in the ultimate salvage of the ship, although her value as a fighting unit after the damage from the torpedo would probably be little or nothing for the time being.

The British cruisers "Aboukir," "Cressy," and "Hogue," which were sunk by the German submarine "U-9," were, of course, not ships of the most modern type. They, however, represent a very excellent type of ship of some 15 years ago, and the fact that each of them sank as the result of a blow from a single torpedo indicates plainly enough the fact that a ship of very little age soon becomes practically out of it when subject to the danger of submarine attack.

The more recent sinking of the dreadnought "Audacious" brings this thought more forcefully to our minds.

The submarine, as you know, is not at all a new idea; in fact, some very excellent conceptions of submarines are quite old. Any one desiring to investigate this fact has but to read the interesting and complete work on "Submarine Navigation," by Allen W. Burgoyne, who rehearses the various types of submarines projected or

*Journal of the Franklin Institute.

Successful submarine attack at close range.

undertaken by all manner of people since before the beginning of the Christian era.

The list of inventors includes men of all nationalities and from all walks of life: doctors, clergymen, lawyers, military men, and mechanics.

Some of the projects were absurd, many were never undertaken, but others had excellent ideas, and were perfectly practicable, except in one essential particular: a proper prime mover for propelling and auxiliary power.

The early boats were, of course, propelled by hand, no other power being then known, and it takes little imagination to understand how laborious this was and how little speed or control could be expected from a craft so propelled.

It was not until steam had been used as a motive power in surface ships for many years that a really operable submarine was produced, and not until the development of the internal-combustion engine and the storage battery that the submarine became the well-developed instrument that we know to-day.

Strangely enough, there has been of late a return from the internal-combustion engine to steam in certain instances for surface propulsion, but so far the storage battery holds undisputed sway as a source of power for under-water work.

The submarine at present must carry two entirely distinct and separate sources of power, one for surface work and one for submerged work, and the storage battery per unit of power is very heavy.

I have kept before me for years a sign that reads: "The man who says a thing is impossible is apt to be interrupted by somebody doing it." So I shall not say that any means of under-water propulsion other than storage batteries is impracticable, but at the present time no other practicable means is apparent, and it is this very fact that is the greatest restriction confronting the submarine designers and builders.

The essential features of any submarine from a military point of view are surface speed, surface radius, submerged speed, submerged radius, and armament.

SURFACE PROPULSION.

The early successful submarines had gasoline engines. These were later superseded by heavy oil engines of the Diesel cycle—first, four-cycle engines, and, more recently,

Observing by means of the periscope.

two-cycle engines, of which several types have been used. None of these can be said to be perfect yet, but great improvements have been made and are still making.

The high pressures and temperatures that occur in the Diesel engine result in stresses that are serious, and the high speed and comparatively light construction that must be obtained in submarine engines give a chance for trouble that might not exist in a slow-going installation.

STORAGE BATTERY PLANT.

The safety and success of the attack of a submarine depend to a great extent on her ability to approach the enemy while submerged and to remain submerged for a long while. In a high-sea engagement the enemy's fleet may naturally be assumed to be under way at some speed, so that the development of the sea-going type, to which some reference will be made later, will logically include some increased submerged speed and considerable increased submerged radius for maneuvering in the vicinity of the enemy for a long period.

Increased submerged speed and increased radius of action submerged will make the batteries proportionately larger than are at present used.

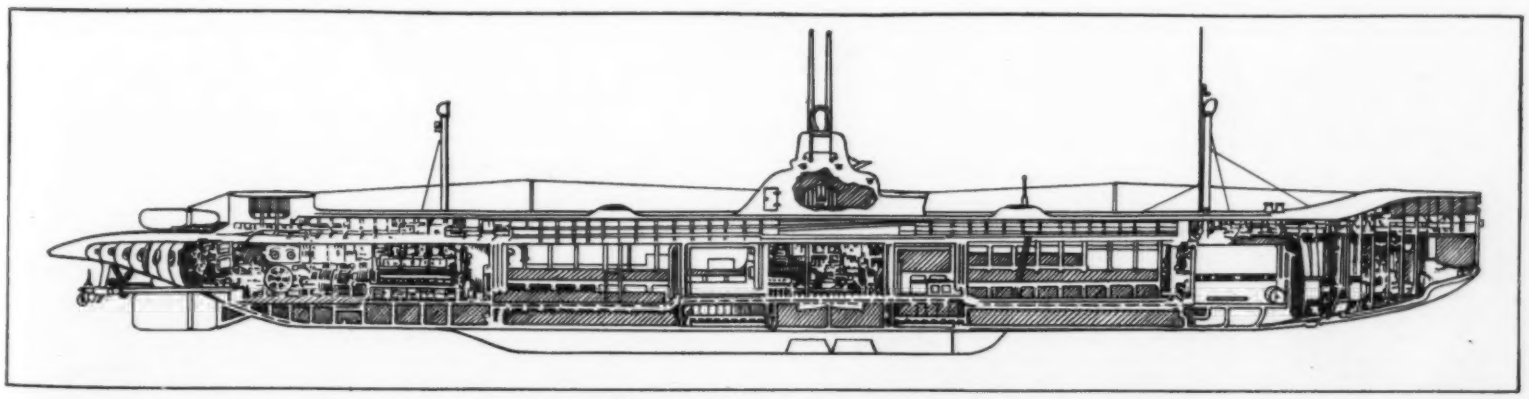
In the case of the sea-going type of submarine the design of the storage battery requires study in order to get the battery best adapted to obtain the maximum speed submerged and the greatest radius of action along wi h a reasonable length of life.

ELECTRIC PROPULSION ON THE SURFACE.

Owing to the mechanical difficulties involved in large reversible Diesel engine plants, it may be found advisable to design for a purely electrical propulsion—surface as well as submerged—using Diesel-driven generating sets, or turbine-driven generating sets driving motors on the surface. The present difficulty in the way of such installation is the size of direct-current motors required for constant duty on the surface.

To save space and weight, voltage up to 500 volts would suggest itself as feasible, or, as a compromise, to use 500 volts for surface running and 250 volts when running submerged, which would involve practically the same voltage as at present used on submarines.

The electric propulsion would involve one or more direct-current generating plants, and the propeller shafts



Longitudinal section through a typical German submarine.

would be supplied direct from the generators for surface running and from the storage battery for submerged running. The speed control obtainable from such an equipment is ideal.

Some propositions have been advanced for obviating the necessity of a duplicate propelling plant, utilizing the surface cruising engines also for submerged work. One of the most prominent of these, up to date, is the Del Proposto system, proposed by a Belgian engineer of that name.

To quote in part from a paper read by Mr. Del Proposto, the system is based on the following principles:

"The compressed air can first be regarded as a fluid with a potential power due to its pressure, and then as a chemical composition. Thus it can serve twice for producing energy: first, in a compressed-air motor, and then as feed for an internal-combustion motor. This twofold use of the same air for producing energy leads, evidently, to a reduction in air consumption per horse-power and a given lesser quantity of air to be stored on board for developing a given quantity of energy, and therewith also a reduction in the required weight of air tanks. Thus we come logically to the following conception of the boat, viz.:

"A boat or submarine diver of which the propulsion on the surface is ensured by an internal-combustion motor, which, during such run, can also actuate a compressor which stores air at high pressure in the tanks. During under-water runs the compressed air, reduced to a suitable compression by means of a reducer, passes first through a compressed-air motor, which need be no other than the compressor before mentioned, if its construction allows it, or one or two cylinders of the internal-combustion motor. Then the air is drawn up by the internal-combustion motor, which under water continues working exactly as on the surface. The air which has escaped from the compressed-air receptacle and drawn up by the internal-combustion motor remains in a closed vessel, but if we take note that this air has not lost its chemical qualities nor its composition, and, therefore, can well serve for the breathing of the crew, it is suitable to let it first escape inside the boat, whence it is drawn by the internal-combustion motor.

"In arranging the escape openings of the compressed-air motor on one of the ship's ends at the side where the crew usually is, and the suction of this motor at the opposite end, we establish inside the boat an artificial air current, continuously ensuring strong ventilation.

"It may be noted that, the escape passage of the compressed-air motor and the suction of the internal-combustion motor taking place in the same connecting tubes, it would be necessary to establish there a receptacle of great capacity, which would serve as regulator, intended to avoid the pressure variations at the entry of the internal-combustion motor. In the above indicated arrangement the whole inside of the boat acts as intermediary tank, and, consequently, the unchangeability of the pressure could be easily maintained. Seeing that the air which serves for the production of energy is used for ventilation of the boat, we have thus an automatic renewal of air without recourse to special apparatus."

I believe the construction of a boat embodying these principles was undertaken, but I am of the impression that its advantages were not all that had been expected. It serves, however, to indicate a possible line of solution, and one which would be desirable if it could be attained.

There have recently come forward several propositions of a somewhat different character, but a proven installation has not yet been produced.

PROPELLERS.

One of the most difficult problems to solve in connection with the design of a power plant for submarines—in fact, a problem without exact solution—is the design of a propeller suitable both for surface and for submerged navigation. There are two conditions to meet, which call for two distinct propellers. Broadly speaking, the first condition is to obtain a certain speed with a certain resistance to propulsion on the surface; submerged, the speed may be the same, but the resistance has increased, because the body to be pushed through the water has increase in volume and has changed shape. It is impossible to have two distinct propellers, and a propeller capable of having its pitch mechanically changed to suit conditions for the sizes now used in submarines has proved difficult to obtain in practice and of less efficiency than a compromise propeller to meet both conditions.

We are therefore driven to the design of a propeller to meet both conditions as near as possible. To do this we must decide which one is to be favored. Either the surface high or cruising speed or the submerged high or cruising speed can be favored, according to whether we are limited in obtaining power units large enough or in carrying fuel or storage battery capacity.

A safeguard is to design the propeller with an excess of area to make up for errors due to the non-fulfilment of the true pitch in both conditions and to the increase in slip due to the propeller turning faster to meet the increased resistance submerged, owing to the pitch of the compromise propeller being smaller than the pitch required for surface work. Hence the speed load curve of the electric motor should be higher in point of revolutions per minute than that of the internal-combustion engines. But this is not always possible, owing to the characteristic curve of electric horse-power required at different speeds, which is low in point of power at low speeds, compared with the engine load speed curve, which is nearly a straight line, and one has to keep the speed of the motor lower than the speed at corresponding power of the engine in the range of low speeds in order to meet the ship's electric horse-power curve.

Thus, given the engine's speed load curve, the safest course seems to be to design the motor so as to be correspondingly lower in speed for equal power in the range below half load, and higher in speed than the engine at corresponding powers in the range above half load. Then design the propeller with pitch between the pitches required for two propellers designed for each condition separately, with an excess of area and favoring the condition where there are deficiencies, and, finally, making the propellers with adjustable blades so as to be able to modify the pitch during the trial trip.

This is my idea of meeting conditions, subject to further observations during trials to come in order to discover points open to correction. Past performances only, compared with future results, can point out the most effective way for meeting and overcoming the difficulties in this line.

SAFETY V. EFFICIENCY.

The tendency of the United States Navy Department's requirements is in the direction of multiplicity of safety devices and escape hatches, greater watertight subdivisions, etc. While this may increase efficiency by giving the crew greater confidence, additional hatches are really a source of danger, and close subdivision interferes with economical arrangement of the interior.

I believe the dare-devil type of man who would naturally choose submarine service would rather have more effective means for dealing with the enemy and take any reasonable chance on his own safety.

Of course, the Navy Department, under a Government such as ours, has to keep the political and public-opinion sides of the question in mind.

DEPTH OF SUBMERGENCE.

Heretofore all United States submarines had to be subjected to a test depth of 200 feet from the axis, while all foreign submarines have been contented with 40 meters. This, in itself, is a penalty on the design of United States submarines, adding, as it does, to the weight of the hull and so increasing the size and cost of a given type of boat.

At the present time the opinion seems to be growing in the United States service that a test submergence depth of 150 feet is sufficient. This means probably that, with improvements in design and growing familiarity with the handling of the vessel, the submarine operators are becoming satisfied that they will be able to avoid accidental submergence beyond this depth if they can check the sudden downward movements at all, and, if they cannot stop her before reaching 150 feet, the chances are they could not before reaching 200 feet, anyway, and therefore adopt 150 feet and save weight for other purposes.

As I understand it, the 200-foot test was originally based on consideration of the depth along the Atlantic coast, 10 or 15 miles from shore, on the theory that a vessel might go to the bottom and still be O. K. if she could stand 200 feet.

As in all other types of naval ships of war, the submarine has two general rôles, defensive and offensive.

Defensive operations include:

Harbor defence, which, at the beginning of submarine development, was regarded as a primary duty.

Coast defence, an amplification of harbor defence, rendered possible by increase of radius of action and habitability, in virtue of which the submarine may be used to prevent landing in force or other operations along the coast anywhere within limits, equal, roughly, to early half their radius of action.

Offensive operations include:

Destruction of vessels with which the enemy attempts to either hold or control the sea or to carry on military operations.

Attacking the enemy's ships and ports.

Operations in conjunction with the fleet on the seas.

On account of the extensive coast line of the United States, submarines in number seem essential for use in *defensive operations*.

On account of the geological location of the United States, the value of submarines for attacking enemies' ports is, for over-sea enemies, smaller than is the case with European powers. In their use for the destruction of vessels with which an enemy attempts to hold the sea or for use in conjunction with the fleet, a type of boat somewhat different than that required for the strictly defensive operations would necessarily result.

From the point of view of the United States, it would seem that the desideratum is an adequate number of submarines that will actually do what is required of them theoretically; i. e., some for defence near our home ports and bases, and some for operations with the fleet on broader defensive lines. To be able to obtain an adequate number it is essential that the necessary features be obtained with the least possible displacement and at the least possible cost.

For the protection of the harbors on the east and west coasts of the United States, it has been estimated by a naval authority that there should be a group of five coast defence submarines and one suitable tender stationed at each of the harbors and places which are considered worthy of protection for strategical reasons.

It has been estimated that for the proper protection of the east and west coasts of the United States there should be a total of fifty-five coast defence submarines on the east coast and a total of forty-five coast defence submarines on the west coast.

No mention is made above of submarines for the defence of our over-sea possessions, such as the Panama Canal, Atlantic and Pacific ends, Guam, Hawaiian Islands, and the Philippines, but it is believed that at least one mobile tender in combination with a group of five coast defence submarines would be needed in each such locality, with probably several groups in the Philippines, to prevent effectually the operation of a hostile fleet in these waters.

One occasionally reads of submarines of destroyer speed, which to the layman appear entirely practicable and to the military man highly desirable, but to the submarine man it seems impossible, and certainly is to-day, meaning, as it does, about 30 knots on the surface.

The advent of the large sea-going type of submarine is a logical development in submarines, and there seems little doubt but that in the future two distinct types of submarines will be recognized to be needed, namely, a small type designed for harbor defence or coast defence, and a large type or sea-going submarine, capable of accompanying the fleet even to the waters of the enemy's country and supporting the battle fleet in a fleet action.

The essential features of the small type have already been worked out and are in successful operation and generally known, so that new development of the equipment of these boats will naturally be slow, but the conditions that the sea-going type must meet give an opportunity for increased development, particularly in the propulsion plant, both for surface work and submerged operation.

The present type of submarine, of which our navy has a considerable number, have a surface speed of from 12 to 14 knots, with a radius of action at 9 or 10 knots of from 1,500 to 4,500 miles. Such boats range from 250 to 550 tons displacement submerged, and have fairly small reserve buoyancy.

For a purely defensive type of submarine the 4,500-mile radius is, in my opinion, entirely unnecessary, and requiring it results in a boat of consideraby greater cost and size than is necessary to perform the work which it is intended to do and is capable of doing.

The sea-going, fleet speed submarine, to be used in conjunction with the fleet, is quite another matter, and the provision of long radius of action is not only justifiable, but necessary.

Considerable prominence has been given recently to the giant submarine projected by our Navy Department. What is really aimed at is a sea-keeping submarine for service with the high-sea fleet.

Public policy prevents my entering into details of the vessel desired, but there is no impropriety in my discussing briefly the general principles of such a design.

Foreign powers, by which I mean England and France, have undertaken, but not yet completed, a submarine of some 18 to 20 knots surface speed and with submerged speeds of 13 or 14 knots.

Complete details of such vessels are not available, but they naturally lead to dimensions far in excess of those of submarines now in our service.

For submarines of the coast or harbor defence type it is usual to have a hull of circular cross-section, sometimes modified toward the extremities into an ellipse, with its major axis horizontal or vertical, as required by conditions.

After exhaustive investigation I am convinced that for vessels of moderate speed requirements this form is, all things considered, the best.

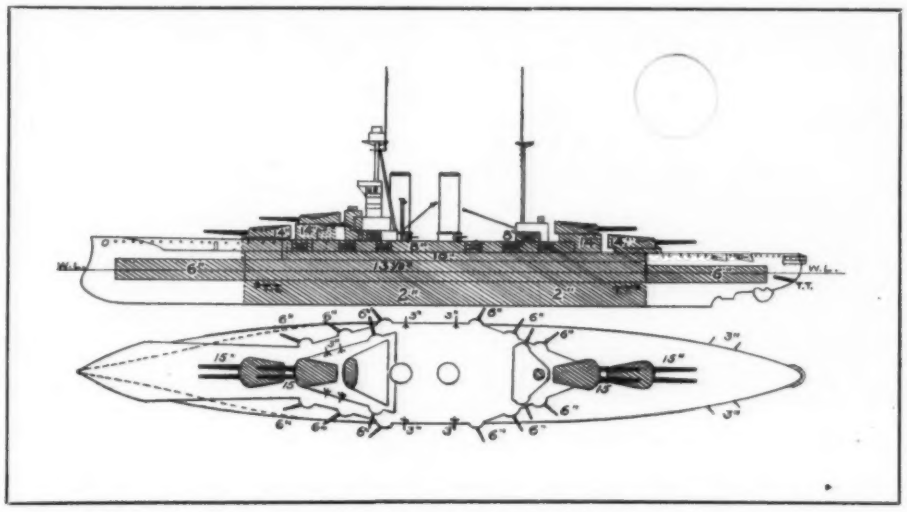
(*To be continued.*)

The U. S. Geological Survey has thus far surveyed topographically about 1,200,000 square miles, or nearly 40 per cent of the United States, as well as 170,000 square miles in Alaska. Nearly 2,300 quadrangels have been mapped on various scales, generally 1, 2, or 4 miles to the inch. These maps show minute details, even to individual houses existing at the time of the survey. The extent to which they are used is shown by the fact that more than 1,500 copies are sent out daily on an average.

The Super-Dreadnought

THE influence of H. M. S. "Queen Elizabeth" on the progress of the Allies' attack on the Dardanelles forts has given the *coup de grace* to the advocates of smaller battleships. In the very early days of the war we stated that among the problems that had faced military and naval engineers during the many years that they were building material which was never tested in hostile operations, the greatest of all naval problems—the dreadnoughts versus White ships—would be settled. We must admit that at that time we expected the great test to be made in a general fleet action, and in the absence so far of that ultimate trial, it is still open for the advocates of the smaller vessels with mixed armament to claim that the decision is not final. But they must be very determined opponents indeed who refuse to admit that the dreadnought battleships and cruisers have fully justified the advisers of the Admiralty in their decision to build them. The "Queen Elizabeth" has, however, given us all a surprise, not only by her sudden appearance in an unexpected quarter, but by the effect she has produced. In all discussions we have heard, and in most we have read, on the relative value of the big and the medium-sized battleship, the basis of comparison has always been two hostile vessels or fleets in action; attention has rarely, if ever, been directed to the attack on permanent land defences. It was either tacitly assumed that a fleet would always have to run the gauntlet of a general action before an attack on shore defences could be attempted, or Admiral Mahan's dictum, that a fort could always beat a ship of equal monetary value, had been carried further than the author intended. In the first alternative, competition with enemy ships was the criterion, and as the question of the attack on forts was dependent upon the power of a fleet to destroy its opponent on the high seas, it was neglected as of only secondary importance. The second alternative, that powerful forts could not be successfully attacked, has presented the revelation of the war, both on land and sea, and it is hardly surprising that it escaped attention. Until the Germans showed us what could be done against great fortresses it was the general belief—as much, no doubt, in Germany as in other countries—that such defences could hold out for long periods. Until the allied fleet, with enormous guns of long range aiming into the blue, under the direction of aeroplanes and watching ships, effected the destruction of the forts in the Dardanelles, no one had considered the possibilities of such things; the surprise the Germans gave us ashore, we have given them afloat, and forts as a means of defence, at least forts of the kind we now know, are discredited. Admiral Mahan's dictum must clearly be re-written or re-read. That great critic sympathized with Sir William White's views about the size and armament of battleships, but it is probable that, had he lived longer, and had witnessed the effect that the 15-inch gun has had at the Dardanelles and that the 13½-inch guns had in the North Sea action, he would have somewhat modified his views.

The "Queen Elizabeth" has opened new and astonishing possibilities which must be causing grave anxieties in Germany. She is but one of five sisters; one other, the Warspite (Devonport) may already be at sea, she was laid down about the same time, and was due for completion in October last. The "Valiant" (Clydebank) and the "Barham" (Fairfield) were due for completion last month, the "Malaya" (Elswick) should be drawing toward readiness for sea. Speaking of these vessels, when introducing the last navy estimates, Mr. Churchill dealt with the guns at some length. The passage is of more than ordinary interest at the present moment and we quote it in full: "One of the most important decisions that the Admiralty have had to take for many years was the advance from the 13.5-inch gun to the 15-inch gun. Two years ago we knew that other countries had already decided, and had actually begun, in some cases, to adopt a number of more powerful weapons than we possessed in the 13.5-inch gun. In the "Queen Elizabeth" type we wished also to have exceptional speed without any loss of gun power or protection or undue increase in displacement. We had thus to give up one of the five turrets to find room for the extra boiler power, and in order to maintain our gun power we had to increase the caliber of the guns.



Outboard profile and deck plan of super-dreadnought "Queen Elizabeth," showing guns and armor plate.

Thus we had eight 15-inch guns instead of ten 13.5-inch guns. There is no great difference in cost involved in this. But what is remarkable is that while other countries were debating and experimenting we acted. We ordered the whole of the 15-inch guns for the ships of the 1912-13 programme without ever making a trial gun. We trusted entirely to British naval science in marine artillery, and to the excellence of our gun-making system and to the quality of British workmanship. When the first of these 15-inch guns was tried a year ago it yielded ballistic results which vindicated, with what is to the lay mind marvellous exactitude, the minutest calculations of the designer. It is the best gun we ever had; it reproduces all the virtues of the 13.5-inch gun on a larger scale, and it is the most accurate gun at all ranges that we have ever had, and as it is never pressed to its full compass by explosive discharge it will be an exceptionally long-lived gun. Its power may be measured by the fact that whereas the 13.5-inch gun hurls a 1,400-pound projectile, a 15-inch gun discharges a projectile of nearly a ton in weight, and can hurl this immense mass of metal 10 or 12 miles. That is to say, there has been an increase of rather more than 30 per cent—I am purposely vague on this point—in the weight of the projectile for an addition of 1½ inches to the caliber. This increase in the capacity of the shell produces results in far greater proportion in its explosive power, and the high explosive charge which the 15-inch gun can carry through and get inside the thickest armor afloat is very nearly half as large again as is the charge in the 13.5."

If one ship with these fine weapons could do what the "Queen Elizabeth" has done, what may not four more do? New vistas of the part of Great Britain in the war and the influence of sea power are offered. These considerations must have occurred to the Germans, and we may well believe that the thunder of the 15-inch guns in the Ægean Sea sounds all too close to their ears.—*The Engineer.*

The Indicating and Recording of Time

THE indication of time has long been one of the most important factors in the history of the world. Even the primitive peoples had some crude methods of telling time, usually by the sun, and one of the first implements used for the purpose was a vertical pole stuck in the ground to establish the noon mark. Representative types of early time-keeping apparatus and mechanisms from various countries are to be seen in the U. S. National Museum at Washington, D. C. This collection consists of permanent and portable sundials, hourglasses, time candles and lamps, a large series of watches and watch movements, and clocks, including a water clock of the seventeenth century.

Among the sundials, which are perhaps the best known of the early time indicators, is a model of one used by the Montagnais Indians of Canada, consisting of a pole set vertically, the shadow of which was marked in the snow by each hunting party to indicate the time of its arrival to the Indians who followed, thus making the passage of time calculable. Other interesting specimens are brass and ivory pocket sundials of the fifteenth and sixteenth centuries. There is also a ring dial which, when held vertically, permits the sun to shine through a small hole on one side of the rim and register the hour on a scale on the opposite side. Vertical and horizontal dials from many countries and latitudes, dating from the fifteenth to the twentieth centuries, are represented.

One of the most primitive time recording devices employed by the Chinese and Japanese, was a knotted wick about 2 feet in length, which smouldered without breaking into flame, and indicated the passage of an hour by the time consumed in burning between two knots. King Alfred is credited with having established a system whereby 12-inch wax candles were divided into equal distances; relatively a third of an hour being required to burn an inch. A candle of this type, but only 10 inches in length, is exhibited in the museum collection.

Philippe II. of Spain is supposed to have used an oil lamp for indicating time, the decrease in the amount of oil being shown by graduations on the glass reservoir. It was designed especially for night use; the graduations started at the top, with the mark IIII, passed downward to XII, and then from I to VIII, covering the period of winter darkness. A similar lamp is in the National Museum exhibit, classified as a pewter time-indicating lamp, marked for the hours nine to six, and was collected in 1900 in Nuremberg by Dr. Samuel P. Langley, late secretary of the Smithsonian Institution.

Sand glasses are represented by seven specimens of various types indicating 3 minutes, ¼ hour, ½ hour, and 1 hour, and one German set of four hour glasses probably of the fourteenth century. The hour glass is said to be the invention of Luitprand, a monk of Chartres, who, near the end of the eighth century, revived the art of glass blowing. These instruments are still popular with many clergymen, and it is understood that one is in daily use in the British House of Commons.

Clocks operated by water power date back as far as 300 B. C. in Egypt, and although their history is somewhat vague, it is believed that the earliest ones indicated "hours" of uneven length, while those evolved during the seventeenth century and later were simpler and showed even periods. Clocks of this description and of this period are known as Clepsydras; one with an alarm attachment was collected for the museum by Dr. Langley in Paris. It consists of a hollow drum, partly filled with water, suspended from an oblong frame by two cords, the lower ends of which are wrapped about the shaft of the drum. When the cord is wound about the shaft, the drum is at the top of the frame, and if released would descend rapidly, unwinding the cord as it goes, were its speed not regulated by the action of the water which flows slowly through a series of seven compartments within the drum, causing a drag or counterbalance to the action of gravity. The ends of the shaft act as indexes pointing to the hours marked on the frame.

The date of the introduction of clocks worked by weights is not definitely known, but it is supposed that they did not appear until the thirteenth or fourteenth century, and that John Megestein of Cologne invented the escapement. The museum displays a number of these clocks, including a ship's clock which rings "bells" in sea-going style.

Portable time pieces appeared shortly after 1500 as the invention of Peter Henlein of Nuremberg, who employed a long ribbon steel spring to drive the mechanism of his watches.

The museum collection of watches and movements numbers several hundred, and illustrates the development of the mechanical part of the watch, making it possible to compare the work of many early watchmakers of this and other countries.—*Bulletin of the Smithsonian Institution.*

Electro-Percussive Welding

AN interesting variation in the many methods for the electric welding of metals, particularly where the two parts are different metals, was described last fall at the meeting of the Electro Chemical Society by C. E. Skinner and L. W. Chubb. In this system, which is called an electro-percussive method, a condenser discharge is passed between the ends of the parts at the moment when they are pressed together by mechanical force. An intense heat is generated so suddenly that it is entirely localized, and there is no time for the unequal conduction of heat through the bodies of metal, and the adjoining ends will be melted, whether the melting points be low or high. For this reason metals of different kinds can be welded together independent of their electrical resistance, melting point or heat conductance. For example, lead and iron can be thus welded, but such joints will not be permanent.

Recognizing Vocations from the Teeth

A Phase of Occupational Diseases That Has Received Little Attention

If we except phosphorus poisoning in the match industry, there is in the present day movement of caring for the workmen in the various trades one phase of the occupational diseases of which we hear comparatively little. This is the effect of different trades or occupations on the teeth and is ably discussed by Dr. M. Krause in a recent number of *Die Umschau*.

Not only do the teeth become decayed or otherwise diseased, or changed in shape, but they even are worn or dissolved away to such an extent that only stumps remain, and this due to a variety of causes, not only to lack of care.

A good example of the first-mentioned case is furnished by confectioners or candy makers whose front teeth particularly, are prone to decay followed by subsequent discoloration of the exposed dentine, due to the constant breathing in of sugar dust.

Fig. 1.—Confectioners' caries.

With workmen in chemical factories, where acids are manufactured or used in large amounts, "the process of destruction is not in any respect like the ordinary tooth decay but is a decomposition of the inorganic constituents and a devitalization of the organic constituents of the teeth."

In describing the effects of acids the author, who relies to a considerable extent on what is told to him, tells us that "the subjective sensation is alleged to be above all, a feeling of dullness in the affected teeth; these become so sensitive to change of temperature and to contact with sour, sweet and salty foods that every partaking of nourishment almost becomes a torture. This sensitiveness disappears when the process of destruction has assumed greater proportions." (Figs. 2 and 3).

Fig. 2.—Acid necrosis of the large incisors of the upper jaw of a chemical factory workman.

"The front teeth on account of their location and arrangement are the first to suffer since they are earliest exposed to the injurious influences."

It is observed that in metal workers, who are neglectful of the care of mouth and teeth, almost half of the exposed surfaces of the teeth, from the gums upward are covered with a dirty green coating. The workmen believe that they have "verdigris" on their teeth.

Dr. Krause was repeatedly able to convince himself that "as this coating may still be detected after a change of occupation of some duration, it may be designated and utilized as an important characteristic indication of occupation."

This deposit is caused by the "unavoidable metal dust which arises during the work and settles on the teeth during breathing, combining with the tartar coating of the neglected teeth."

The wearing away or roughening of the edges of the teeth is well illustrated by shoemakers who continuously use nails and brads of different sizes, which they usually

Fig. 3.—Acid necrosis of the lower middle incisor.

hold in the mouth and which thus serves as a handy container. "When a nail or wire brad is required the tongue pushes it between the biting surfaces of the incisor teeth. There it is held fast until required for use."

This results in the formation of coarsely jagged edges on the incisor teeth.

"Only when the nails are continually pushed between the middle incisor teeth will semicircular substance erosions sooner or later result, which are similarly found in upholsterers."

As to the effect of their trade on their teeth, we quote

Fig. 4.—Teeth of a glassblower, showing the rhombic opening formed by the revolving pipe.

the following in regard to glassblowers: "In order to form the glass mass into a desired shape, glassblowers make use of a long iron tube, sometimes provided with a brass mouthpiece. This is the so-called 'glassblower's pipe' which is held between the lips and teeth and is turned during blowing. From this worn concave surfaces result on the middle incisor teeth, which when closed, show a rhombic or diamond-like opening characteristic of glassblowers." (Figs. 4 and 5).

All those whose occupations compel them to use th sewing needle, that is, tailors, modistes, corset makers, etc., show "slit shaped grooves on the cutting edges of the incisors, and according as the possessor is right or left handed, running from right to left or *vice versa*, either slanting or in the center of the cutting edge in the direction of the cutting plane." (See Fig. 6).

The cause is that most workers in this trade, male and female, bite or tear off the thread with the incisor teeth before threading their needles.

"If they have the habit of firmly holding pencils between their teeth occupational indications are also evi-

Fig. 5.—Teeth of a glassblower. The middle incisor teeth show round worn off surfaces.

dent on the front teeth of teachers and draughtsmen, thus causing concave substance erosion."

"It has been proven that the habit of placing nails in the mouth and replacing those not used in a box in common use has been the cause of the transmission of syphilis. Also tuberculosis and other infectious diseases are certainly spread by such abuses."

Syphilitic infection has likewise been reported among glassblowers. For this reason shoemakers, upholsterers and glassblowers should be cautioned as to the danger of their manipulations, and the abolition of these abuses vigorously demanded. "By this means a great amount of misfortune will be prevented."

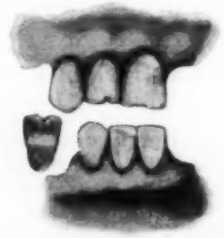


Fig. 6.—Teeth of a dressmaker. Note the grooves which have resulted from biting off the thread.

The article concludes with this excellent advice: "As experience in other occupations has shown that notices and posted regulations do *not* receive the deserved attention, we need not expect much result from this method in workshops. The lever for enlightenment and education should already be applied to the apprentices while at the trade schools. It is there that we should by means of words and pictures emphasize the great danger to life and health of such customary abuses."

Relics from the Second Grinnell Expedition

Through the recent death of Mr. Amos Bonsall, the last survivor of the second Grinnell expedition, which set out for the Arctic regions in May, 1853, in search of Sir John Franklin, there has come into the possession of the U. S. National Museum several relics and mementos of that notable undertaking, which have been donated to the museum by the daughter of the explorer. The collection includes gold and silver medals presented to Mr. Bonsall by the British government, and a daguerreotype made after his return from the expedition in 1855. A pair of polar-bear skin boots made by him an English rifle, an English knife, with a carved ivory handle of Eskimo manufacture, and a "sou'wester," originally from the Arctic expedition of Sir John Ross, all used by Mr. Bonsall during his explorations, and a pair of skin stockings and fur boots manufactured by the Eskimo are also on exhibition.

This exhibit is displayed in the north hall of the older National Museum building in connection with other Arctic relics. It recalls vividly the hardships suffered by the rescue party sent out in the brig "Advance," under the direction of Dr. E. K. Kane, U.S.N., which were so graphically reported by the commander upon his return.

Some of Mr. Bonsall's experiences were very thrilling; his report of a sledge journey made by six of the crew and himself to establish provision stations along the coast of Greenland is a remarkable story of adventure. It records a most perilous trip, over the ice and frozen land, in September and October, 1853, and when the temperature was far below zero. At the very outset, their sledges broke through the ice, precipitating several of them into the sea. Shortly afterward they came to an impassable opening in the ice extending for miles on either side of them, forcing them to await the rise of the tide to close it up. The author mentions one night's sleep on melting ice which soaked their buffalo robes, rendering the members of the party "extremely cold and uncomfortable"; incidentally their socks froze to the soles of their shoes. Sometimes the cold was so severe that they could not sleep, in spite of their exhausted condition after the forced march of the day. The fuel gave out, the only watch key was lost, preventing the recording of time; all the thermometers were broken, and nearly every member of the little band suffered from frozen feet, fingers, or faces.

Despite their misfortunes and sufferings, they established three *caches* of provisions, marking each with a cairn of rocks. Their progress was often very slow, some days only eight or ten miles were covered, owing to the rough ice, cracks and barriers encountered, but on others they managed to make as many as twenty-five. Often they had to ferry their sledge and themselves across stretches of open water on cakes of ice, a very dangerous undertaking.

On another trip in March, 1854, a rescue party, of which he was a member, suffered even more severely, and all of them were ill for some time after their return to the ship, from delirium, scurvy, frost bites, and other causes. Mr. Bonsall was the first to return with directions for the care and attention of the others, who, when they arrived, were covered with frost and ice, and so chilled and exhausted that they were unable to recognize their comrades on the "Advance." For sixty-six hours they had been constantly on the move, with very little to eat and even less to drink, during which time they had traveled between eighty and ninety miles, most of the way dragging a heavy sledge laden with four helpless men. As a result of this exposure, two of the men died, and several were forced to undergo amputations of frozen members, but the others recovered after a trying siege which turned the ship into a hospital of sick and insane men.

The tale of adventure connected with the few remaining relics of this heroic band, of which Mr. Bonsall was a member, makes an interesting page in the records of American Arctic explorations.

Italian Military Aeroplanes

Interesting Types of Craft for Air and Water

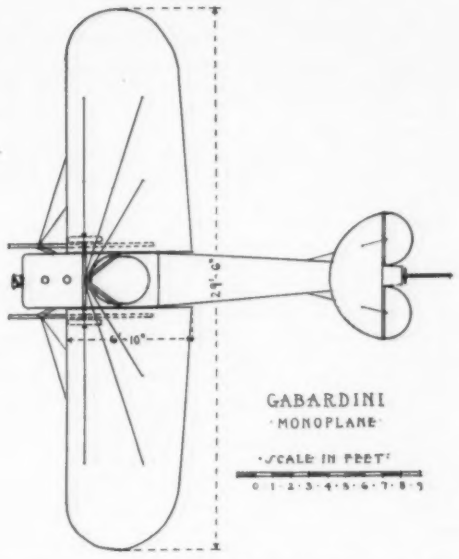
By John Jay Ide

MILITARY aviation in Italy dates back to the winter of 1908-9 when Wilbur Wright after his triumphs in France taught Lieut. Calderara to fly at an aerodrome near Rome. The government did little to encourage the industry and by the end of 1911 there were only 20 aeroplanes in use. There are now almost 200 machines of which 150 are of the latest models.

The machines of domestic design and construction are generally of the monoplane type inspired by Nieuport with sometimes a dash of Blériot or the defunct Hanriot. Only two makes of native biplanes are used: the Spa-Faccioli and one model of the Asteria. Both makes are comparatively slow; fast scouting biplanes have yet to make their appearance in Italy.

Until 1914 all the Farmans used by the Italian army were imported from France. Early last year, however, the Savoia Company which had acquired the manufacturing rights for Henry and Maurice Farman biplanes opened a huge factory at Milan covering 20,000 square yards where large contracts are being carried out for the government. Other foreign machines produced under license by Italian firms are the Blériot, Bristol, Deperdussin and Nieuport.

One of the most successful Italian monoplanes is the Gabardini produced at Camari, Novara. Although the machine is not dissimilar to the Nieuport in general outline there are several special features incorporated in the design. The fuselage, constructed of steel tubes reinforced with wood, has quite an original form. The forward part, from the nose with its 80 horse-power Gnôme to the rear of the cockpit, is rectangular in section. Behind the seats, however, the lower longerons meet and from this point to the stern the fuselage is of triangular section. The above arrangement while giving a good stream-line form allows ample room for the engine, fuel tanks and occupants. The triangular portion of the fuselage can be detached for purposes of housing and transport.



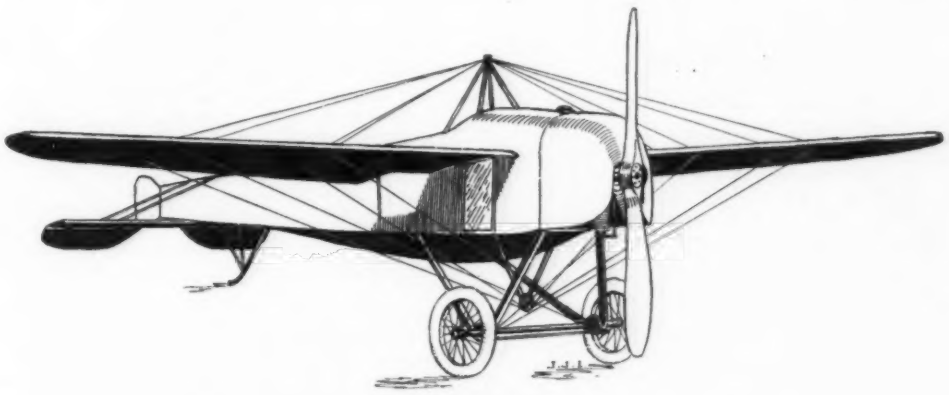
The two spars of each wing are of tubular steel. On these the ribs are loosely mounted so that they possess a certain amount of flexibility when warping takes place. The ribs are of I-beam section with the webs drilled for lightness. The fixed tail plane and elevating flaps are copied from the Nieuport but they are placed well forward of the rudder giving the latter a wide range of movement. All the members of the empennage are constructed of steel tubing covered with fabric.

A lever mounted between the pilot's knees operates the elevators and wing warping. The rudder is controlled through pedals.

The chassis, on Hanriot lines, consists of two skids joined to the fuselage by three struts each. A tubular axle carrying a pair of wheels is slung from the skids by means of rubber bands.

The characteristics of the Gabardini two-seater are as follows: Span, 29 feet 6 inches; length, 24 feet 2 inches; supporting area, 193 square feet; weight (empty), 770 pounds; useful load, 770 pounds; speed, 40 to 85 miles per hour. A hydro-aeroplane model is also produced by the Gabardini firm. It differs from the land machine in dimensions and in the alighting gear, the latter of the two-float type.

Another prominent monoplane is designed by Sig. Caproni and constructed at Vizzola Ticino. Several models are made including single, two and three seaters, generally furnished with Gnôme but occasionally with Anzani motors. With an 80 horse-power Gnôme the two-seater is slightly faster than the Gabardini, due in part to the stream lining of the top and bottom of the fuselage and the small head resistance of the chassis. Sections are cut out of the wings at their roots to improve observation. The Caproni works also build Bristol biplanes under license.



The Chiribiri monoplane.

The Chiribiri Company of Turin build both single and two-seaters equipped with motors of their own make. Their 60 horse-power racer is credited with a speed of 103 miles per hour. The standard models are by no means rapid, doing only about 70 miles per hour with an 80 horse-power motor. The general design presents nothing unusual, the chief claim to distinction lying in the employment of a stationary motor. The Antoni monoplane is also of the conventional type, the Nieuport design being followed throughout, even to the chassis, consisting of two wheels and central skid.

The latest Macchi production is a Nieuport of the "parasol" type (having the plane over the pilot's head) with a Morane landing gear. The Friuli monoplane is a small Blériot type, single-seater, equipped with a 35 horse-power Anzani radial motor and a Hanriot landing carriage. Very few machines of this make are used in the army.

Biplanes and monoplanes are made by the Asteria Company located at Turin. Both types are driven by propellors instead of the more usual tractor screws. Gnôme motors are used on the monoplanes and Renaults on the biplanes. The only other Italian designed biplane is the SPA-Faccioli manufactured by the SPA automobile firm of Turin. It is a two-seater equipped with a 50 horse-power SPA motor and has a simple two-wheeled landing chassis.

An interesting seaplane is Lieut. Calderara's "hydrovol," a hydro-monoplane of over 60 feet span. The passengers are carried in a hull forming the center float of three, connected by a couple of spars. The axis of the propeller, driven by a 160 horse-power Gnôme is slightly below the huge wings which are mounted almost 8 feet above the floats and joined to them by vertical struts. From the outer struts spring the booms carrying the tail plane, elevators and rudders.

The outer floats, equipped with small water rudders at the stern, are divided into a number of watertight compartments with internal lattice frame. The hull is formed of three skins of wood with sailcloth between adjoining skins. If necessary the wings can be cut away and the central hull used as a boat.

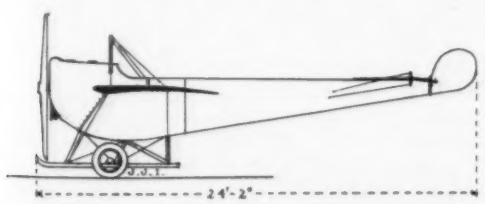
Flying boats—in this case biplanes—are also built by the Bossi Company. Many of these craft have been sold to foreign navies and they are likewise popular in the Italian navy.

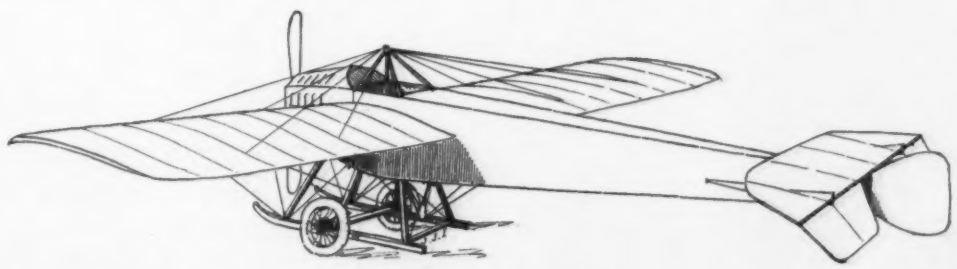
Captain Guidoni supplies Farman biplanes and Nieuport monoplanes equipped with special floats of his own design. In each case there are two long floats, each fitted with parallel fins.

The Italian navy has acquired a large number of Curtiss flying boats, including a duplicate of the "America." The fleet of the 90 horse-power standard model is now being considerably augmented. In this connection a paragraph recently appeared in the daily press to the effect that Italy was about to place an order for 800 aeroplanes with American constructors. Our manufacturers in their present condition would take several years to fill such an order. The training of pilots and observers to man this multitude of machines would be incidentally a formidable task. From an authoritative source I have learned that an order would probably be forthcoming but would not amount to one tenth the above mentioned number. American firms, therefore, need not start work on additions to their plants just at present.

The Italian army machines are divided into squadrons of ten aeroplanes each. Seven machines in a squadron are always on active service while three are held in reserve. The Mirafiori aerodrome near Turin is the principal military flying ground. Acceptance tests for aeroplanes and motors, and examinations for pilot certificates are made here. The central school for brevets is at Aviano and three miles away at Pordenone is the training ground for those who desire to obtain superior brevets. There are several other aerodromes restricted to certain makes of machines. The central marine flying school is at Venice.

The most popular motor is, of course, the Gnôme made under license at Turin. The Anzani radial motor is used to some extent, as are stationary motors produced by FIAT and SPA. These last, however, are generally restricted to airship work.





The Chiribiri from the rear.

Copper Cyanide Plating Solutions*

Valuable Facts Relating to Their Composition, Action and Results

By Dr. Max C. Weber

I HAVE chosen as a subject the working of a copper bath, as this is by far the most extensively used and also the most instructive solution.

There are three things which are necessary for the deposition of metal—current, electrode, and electrolyte. As the electrolyte or plating solution is the most important, I will confine myself to this item.

The object of employing cyanide solutions for the deposition of copper is to be sought in the fact that in such solutions iron does not replace copper, notwithstanding their places in the electrolytic series, a phenomenon which is due to the complexity of the salt in which the copper is present. The complex salt, which makes this feasible, is the double cyanide or sodium copper cyanide, the anion of which is Na, the cation $CuCy_2$; that is, by the action of the electric current, Na travels toward the cathode, $CuCy_2$ toward the anode. In other words, copper is not present in an ionized stage. Under proper current conditions, i. e., not too high current density and a suitable concentration of the solution, Na is not discharged at the cathode, but reacts with an undissociated part of $NaCuCy_2$, as per the following equation:

$$Na + Na\,CuCy_2 = Cu + 2\,NaCy,$$

thus showing that the deposition of copper is a secondary reaction, and that free cyanide is formed. On the anode, the anion $CuCy_2$ combines with the copper of the electrode, forming cuprous cyanide $CuCy_2 + Cu = 2\,CuCy$.

Cuprous cyanide is insoluble in water, but soluble in cyanide solution, and for this purpose the free cyanide generated at the cathode is required. Supposing we have proper conditions—low current density on both electrodes—enough free cyanide is produced on the cathode in order to keep in solution the cuprous cyanide formed on the anode. As the free cyanide of the cathode is really needed on the anode for dissolving purposes, and as in a still solution the mixing velocity is very low, stirring and warming of the electrolytic bath would expedite this matter considerably and bring the bath very near to an ideal stage. However, warm and agitated solutions require a more careful observation on account of which these two items have not as yet been paid the attention they actually deserve.

If too high a current density is used on the cathode, not all the Na ions act reducing on the sodium copper cyanide, but are partly discharged, forming sodium hydrate and hydrogen in connection with the water of the bath:

$$Na + H_2O = NaOH + H$$

This reaction accounts for the development of hydrogen or gasing at the cathode. It means that less copper is deposited per ampere hour and not sufficient free cyanide formed in order to keep the anode clean. Therefore, the solution necessitates the addition of sodium cyanide, otherwise the anode becomes coated and the passage of the current is interrupted. Too high a current density on the anode leads to the same result; covering of the electrode with an insulating film of cupri-cupro cyanide.

In regard to current density, it must be borne in mind that warmed and agitated solutions can be worked with a higher current density than cold ones, and that a density of approximately 30 amperes per square foot is quite feasible without yielding a burned and blistered deposit.

Another feature which is quite interesting is the amount of metal deposited per ampere hour. In a copper cyanide solution which contains the metal in the cuprous state, the same number of ampere hours should yield twice as much metal as in an acid bath, providing, of course, all the favorable conditions are prevailing, i. e., a strong solution, warmed and agitated, worked with a minimum amount of free cyanide at a low current density. As, however, common plating solutions are worked on nearly the contrary conditions, the relative amount obtained from a cyanide bath is much lower. How much lower depends entirely on the relative conditions, and only one feature should be emphasized, which has been mentioned above: that the more hydrogen develops on the cathode, so much lower is the percentage of the metal deposited per ampere hour. A low current density results in a high weight of the metal deposited per ampere hour, while the deposition is slow. A high current density yields a lower weight proportionately per ampere hour, but consuming less time for a certain weight of metal deposited, resulting in a greater deposition of metal per hour.

Furthermore, cyanide solutions yield a finer, more homogeneous texture and brighter metal film than the acid baths on account of the secondary copper deposition and because hydrogen may develop more freely on the cathode in such a solution without fear of burning or blistering the deposit.

These few remarks give an idea how complicated the reactions in a plating solution are, and that it requires skill and experience to procure a satisfactory deposit.

The first part of this paper has shown that the constituent which is essential in a copper cyanide bath is the double salt, sodium copper cyanide, consisting of copper cyanide and sodium cyanide, which is easily formed by adding the necessary amount of each chemical to water. A high-grade sodium cyanide has been obtained for quite a number of years, but copper cyanide could only be procured at prices which made its use prohibitive for technical purposes.

For this reason many salts—one might call them subterfuges—have been used which were intended to substitute copper cyanide and form the same when brought together with cyanide solution. One should bear in mind that whatever copper salt is brought together with cyanide solution, the final compound is the double salt, sodium copper cyanide. Another fact which should not be lost sight of is that one chemical can replace another only to the extent of the requisite elements, and that by the reaction of two such salts, always a by-product is formed which contaminates the compound desired.

This is the case with the copper cyanide. Copper carbonate, copper sulphate, copper acetate, cupri-cupro sulphite have been employed in order to form copper cyanide in connection with sodium cyanide and water. That by these reactions an inert by-product consisting of sodium sulphate or sodium sulphite or sodium acetate or sodium carbonate is formed to a high percentage everyone was aware of, but took it for granted as the product necessary, i. e., copper cyanide was not obtainable commercially.

When using copper carbonate, which is really basic copper sulphate containing a small percentage of carbonate, according to the temperature at which it is precipitated, approximately one half pound of inert matter is formed for every pound of copper carbonate, being composed of sulphates and carbonates. By the use of copper acetate, or cupri-cupro sulphite, this inert matter is still further increased, and for each pound of the compounds used, from nine to ten ounces inert salts are produced. These salts accumulate in the bath more and more with every addition of the respective copper salt, and finally yield such a dense solution, which being overloaded with these waste compounds cannot be worked in a satisfactory manner any longer, the plated articles being blistered and the solutions are of necessity discarded.

The reason for this is that a bath of this kind has a relatively low metal concentration and a much higher one of the inert salts. As a rule, the electric current deposits the metal easiest to discharge, which in this case is the alkali metal. Therefore, as the current density increases an excess of hydrogen is generated, which causes burning, and the current output drops considerably.

After considering this crude method of forming copper cyanide one should remember that the copper in a cyanide plating solution is in the cupro stage, while copper carbonate, copper sulphate, copper acetate are cupri salts, and cupri-cupro sulphite is a mixture of both. This means these salts must be first reduced to the cupro state before they are fit for plating. This reduction is executed at the cost of the sodium cyanide which is actually intended for bringing the copper metal into solution only. Further, neutral copper salts as copper acetate, copper sulphate, and cupri sulphite, when brought in contact with cyanide solutions, form cupri cyanide first, which, being an unstable compound, decomposes into cupro cyanide and cyanogen, which latter escapes into the air, and on account of its highly poisonous character is most detrimental to the health of the plater.

Taking into consideration all the disadvantages resulting from the present method for producing a plating solution, every progressive plater should greet with joy the fact that a chemically pure cupro cyanide is now on the market at a price making its use more economical than that of any other copper salt which has been accomplished by new manufacturing methods worked out by the author of this article.

Cupro cyanide contains nothing but the ingredients necessary in a plating solution—copper and cyanogen—so that by dissolving it in cyanide solution no inert, unnecessary products are added. This enables the plater to have perfect control of his solutions at all times, as whenever metal is needed he adds it in the form of copper cyanide, and, when cyanide is needed, sodium cyanide, thus simplifying matters. On account of its high percentage of metal—it contains 70 per cent pure copper, the rest being cyanogen—solutions highly concentrated in metal can be worked at a relatively low specific gravity. This is a further advantage, as a bath low in density is much more easily controlled than a very concentrated one.

Copper cyanide being a cupro salt, does not consume any cyanide in order to be transferred to the cupro stage, and because of its being a cyanide itself it requires less sodium cyanide than any other copper salt to yield the double salt sodium copper cyanide, the essential constituent of a plating solution. This fact points out a more economical method for producing a plating solution. In other words, it saves money. When one buys a metal salt for plating one should not forget that it is not the price of the metal in the salt itself which constitutes the economy of the salt, but the price at which the metal is put into solution as a double cyanide. It is this economy of the copper cyanide combined with its high technical qualities which makes copper cyanide superior to any other plating salt.

The figures in Table I give a comparison of plating solutions produced with different copper salts and are the results of actual tests. The metal contents of the solutions are the same as in Table I.

TABLE I.

Copper cyanide, 70 per cent copper:		
100 pounds copper cyanide at 42 cents per pound	$42.00	
100 pounds sodium cyanide, 129 per cent, at 22 cents per pound	22.00	
		$64.00
Copper carbonate, 50 per cent copper:		
140 pounds copper carbonate at 14 cents per pound	$19.60	
239 pounds sodium cyanide, 129 per cent, at 22 cents per pound	52.58	
		$72.18
Cupri-Cupro sulphite, termed red copper compound—40 per cent copper:		
175 pounds red copper compound at 30 cents per pound	$52.50	
160 pounds sodium cyanide, 129 per cent, at 22 cents per pound	35.20	
		$87.70
Copper acetate, 31 per cent copper:		
220 pounds copper acetate at 25 cents per pound	$44.00	
193 pounds sodium cyanide, 129 per cent, at 22 cents per pound	42.46	
		$86.46

After continuous operations for two hours it was found that while the solution made up with copper cyanide remained almost constant, that is, the relative proportions of metals and cyanide were practically the same, the solution made up with the other salts became unbalanced. The anodes coating over requiring further additions of cyanide, showing once more that solutions made up with chemically pure copper cyanide gave maximum efficiency.

As so-called copper carbonate was the most extensively used, I gave this solution special attention and found, after considerable experimenting, that in order to obtain a solution with sufficient free cyanide to obtain a fairly balanced solution the following proportions were necessary:

140 pounds copper carbonate at 14 cents per pound	$19.60	
280 pounds sodium cyanide, 129 per cent, at 22 cents per pound	61.60	
		$81.20

These comparative figures vindicate once more one of the most important rules in chemistry—that pure materials not only give the greatest efficiency, but are the most economical.

In the present time, which is distinguished by the endeavor to obtain an end as simply and as economically as possible, where everything is standardized in order to obtain the best results at the lowest cost, no farsighted man can dispute the fact that copper cyanide brings this desired standardization to the plating industry, which means utmost economy and high results.

* A paper presented before the Lewis Institute, Chicago, Ill., and published in *Metallurgical and Chemical Engineering*.

The Formation of Ozone in the Upper Atmosphere—II*

And Its Influence on the Optical Properties of the Sky

By J. N. Pring, D.Sc. University, Manchester

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2052, Page 287, May 1, 1915

It was found that a more valuable yield in the formation of ozone by ultra-violet light is obtained with dry air or oxygen than in the case of the moist gases. This influence of water has been noticed by earlier investigators, and is possibly due to the formation of traces of hydrogen peroxide which is known to react with ozone according to the equation:

$$H_2O_2 + O_3 = H_2O + 2O_2$$

In this series of experiments, air after drying was circulated through the reaction vessel at different pressures. After issuing from the radiation vessel the air was immediately led through the reagent. Measurements were conducted at pressure of 760, 70, and 30 millimeters in the different cases. The same total amount of air was passed in each experiment and exposed to the radiation for the same interval of time (10 minutes). The results showed a great decrease in the formation of ozone with decrease in pressure. Thus, at 760 millimeters pressure the yield amount to 0.1 per cent, and at 30 millimeters to 0.0014 per cent.

Experiments which have been made on the exposure of water to ultra-violet light have indicated that a slight decomposition takes place in accordance with the reaction:

$$2H_2O = H_2O_2 + H_2$$

It has also been stated that when moist air is submitted to the action of ultra-violet light, traces of hydrogen peroxide are formed.

Experiments were made by the writer to detect the formation of hydrogen peroxide by passing 60 liters of moist air through the experimental apparatus during two hours, and leading through a solution of titanic acid in sulphuric acid contained in a small glass spiral washer. No change in color was observed. A comparative test made by taking hydrogen peroxide solution showed that it is possible to detect with certainty the presence of 1×10^{-6} grammes of this compound with the above reagent. In 60 liters of air, this would correspond to a volume of 1.8×10^{-6} per cent. The amount formed under the conditions of the above experiment must therefore be below this value, which is very small compared with the amount of ozone formed. As hydrogen peroxide is decomposed by this last gas, it is doubtful whether any appreciable quantity would be permanently stable in the presence of ozone.

The only method, apart from colorimetric tests with organic reagents, which appears to have been applied hitherto for distinguishing ozone from oxides of nitrogen when at high dilutions is one which consists in passing the gas into liquid air, when ozone dissolves and nitrogen peroxide separates as a solid. This method was applied in experiments made by the writer. A total volume of 66 liters of air, after passing through a concentrated solution of potassium hydroxide and then through sulphuric acid, was led through the reaction vessel, where an arc was formed continuously, and was then passed into liquid air. A period of six hours was taken for the passage of the total volume. After this time, a small quantity of white solid, which appeared to be mainly ice, had collected in the liquid air. On separating by filtration through fine cloth, and then collecting the gas evolved on evaporation in a gasometer over mercury, about a liter of gas was obtained. This did not give any coloration with tetra-methyl base paper, nor, on passing the whole through acidified potassium iodide solution, was any iodine liberated.

Though it cannot finally be stated from these experiments that *no* formation of oxides of nitrogen or hydroperoxide occurs through the influence of ultra-violet light, yet it is shown that the quantity obtained is negligibly small when compared with the ozone.

The experiments show clearly that in the higher atmosphere the conditions are present for the formation of a considerable quantity of ozone, but the data are not available for calculating the magnitude of this equilibrium value.

It may be inferred that as the light of the small wave-length necessary for the formation of ozone cannot penetrate any large distance into the atmosphere, this formation of ozone must be confined to the very high layers of the atmosphere.

THE ESTIMATION OF OZONE IN THE ATMOSPHERE AT HIGH ALTITUDES.

The reaction vessel which was used to enable the application of these measurements in atmospheric determinations was devised so as to be suitable for use in mountain districts, and also for attaching to sounding balloons.

An approximate calibration of the volume of air circulated was made by means of the assumption that this amount is arithmetically proportional to the velocity of the wind. A measurement was then made by placing some pure benzine in the vessel, and after exposing for definite intervals to a wind of known velocity, noticing the loss in weight. Knowing the vapor pressure of benzine at the prevailing temperature, it was possible to calculate the volume of air passed by assuming that evaporation of the benzine would take place to the saturation point. The average of a number of these determinations showed that when the apparatus was exposed to a wind for an interval, during which a horizontal flow of air of one mile occurred, the volume circulated through the vessel corresponded to 5.12 liters.

Estimations of ozone, extending over several days, were made in Switzerland, first at a point near Scheidegg (Wengern Alps), at an altitude of 6,970 feet, and then at a point near the Jungfraujoch, of 11,690 feet altitude.

During these measurements, tests were made for hydrogen peroxide by exposing titanic acid solution in an apparatus similar to that used for the ozone estimation. The color of this reagent remained quite unchanged after exposing for two days at the different altitudes, and under different conditions of weather, thus showing that there was no appreciable quantity of hydrogen peroxide in the atmosphere. It was noticed, on the other hand, that freshly fallen snow or hail gave a very marked coloration with the reagent. It is hoped later to conduct tests with glacier water, as this would be expected to retain the hydrogen peroxide associated with the snow.

In the estimations of ozone, made by means of potassium iodide, it was found that in no case was any potassium iodate formed. As pointed out above, this shows the absence of any appreciable quantity of oxides of nitrogen.

The results of the estimations of ozone showed a mean volume per unit volume of arc at 6,970 feet of 2.56×10^{-6}; and at 11,690 feet, 4.7×10^{-6}.

In order to obtain some idea of the amount of ozone in the higher regions of the atmosphere, use was made of the sounding balloons which are used in meteorological investigations at the Manchester University. These balloons, with the instruments attached, rise to an average height of about ten miles, and then burst. The deflated skin retards the rate of fall of the instruments to the ground. A knowledge of the height attained and the temperature is obtained by a recording baro- and thermograph. The reaction vessel for the ozone tests was of the same form as used in the previous experiments, and was suspended vertically from the balloon together with the other instruments.

A rough calculation of the amount of air which would pass through the vessel during an ascent and descent was made, and it was seen that the exposure of the vessel to a horizontal flow of air of one mile caused the passage of 5.12 liters. Expressing in centimeters, this gives for a displacement of 1 centimeter 0.032 cubic centimeters.

On the assumption that the volume circulated is proportional to the displacement through the air, it follows that during an ascent and descent, the mass of air passed through in grammes is given by $2\ (p - p_1) \times 13.6 \times 0.032$, or $0.87\ (p - p_1)$, where p is the atmospheric pressure in centimeters of mercury at ground level, p_1 that at the highest level reached, and 13.6 the density of mercury. The volume circulated in liters (measured at N.T.P.) is therefore $0.675\ (p - p_1)$.

At a height of about 6,000 meters the temperature is always below the freezing point of the reagent (— 24 degrees), so that reaction must then take place with the solid. It was seen above that under these conditions the method applied did not enable a distinction between ozone and oxides of nitrogen. However, in all measurements made up to 3,600 meters, it was found that neither this gas nor hydrogen peroxide were present in any appreciable quantity. Nitrogen peroxide is of course quite stable at ordinary temperatures, and until dissolved by atmospheric water as nitric acid, any gas formed at high altitudes would remain undecomposed.

By considering the results obtained together with those made on ground level at altitudes up to 3.5 kilometers, the conclusion may be drawn that there is no appreciable amount of hydrogen peroxide in the higher atmosphere, but that there is a considerable quantity of ozone.

The mean values of ozone estimated in the measurements made in the Alps were 2.5×10^{-6} in one volume of air at 2.5 kilometers altitude, and 4.7×10^{-6} parts at 3.5 kilometers. In the measurements made with the balloons above Manchester, the mean volume of ozone between ground level and altitudes up to 20 kilometers gave a value of 2.1×10^{-6}. Even after allowing for the absence of this gas at lower altitudes, the measurements, though only approximate, indicate that there is no very large increase in the amount of ozone at altitudes between 4 and 20 kilometers. However, since at this last height the pressure of the atmosphere is still about 4 centimeters, the amount of light of wave-length below 200 $\mu\mu$, which is necessary to form ozone, would be very small. The probability thus still remains that above this elevation a largely increased content of ozone prevails.

THE INFLUENCE OF OZONE ON THE NATURE OF LIGHT FROM THE SKY.

The results in the above experiments of the approximate determinations of the quantity of ozone in the higher atmosphere supply data which enabled measurements to be made in the laboratory of the depth of color given by this amount of ozone.

For this experiment, a glass tube of 2.8 meters length and 4 centimeters diameter was taken. The walls were provided with side tubes, one near each end, to enable the passage of the ozonized gas through the tube. The two ends of the main tube were covered by thin plates of glass, which were cemented by sodium silicate solution so as to make an air-tight connection. The outside of the tube was wrapped with black paper, and a white paper disk placed over one of the end plates. On illuminating this by daylight and viewing the transmitted light through the other end, the intensity of coloration produced on admitting ozone of known concentration could be observed.

The results given in the table below record the observations made with the tube when filled with oxygen containing different concentrations of ozone. The thickness of the layer of pure gas which is equivalent to this concentration is also given.

Percentage Concentration of Ozone in Oxygen.	Equivalent Thickness of Layer of Pure Ozone.	Color Observed.
0.20	0.55 centimeters.	Color uncertain.
0.36	1.0 "	Faint bluish green.
1.7	4.7 "	Distinct blue color.
2.8	7.8 "	Indigo or steel blue.

It is difficult to compare the color of the gas in a tube of the above nature with that of the sky on account of a large influence exerted by the nature of the illumination.

The above amounts of ozone can be compared with those found in the atmosphere. Taking the amount of this gas found in the Alps at an altitude of 3.6 kilometers as the mean concentration throughout the atmosphere, and allowing 8,350 meters as the height to which the atmosphere would extent if at N.T.P., this concentration of ozone in a vertical section of the atmosphere is equivalent to a layer of the pure gas of a thickness of 4.2 centimeters at N.T.P. On comparing this with the observations made on the color of ozone in a glass tube, it is seen that light which has been transmitted through a layer of gas of this thickness possesses a distinct blue color. In the case of atmospheric ozone at very high altitudes it is probable that the amount of ozone increases and there is also the possibility that the blue or violet color is intensified in this case on account of fluorescence by ultra-violet light from the sun.

With regard to the values obtained in the estimation of ozone at high altitudes, on account of incomplete absorption by the reagent, the experimental error of the measurements would be expected to give too low a value. On account of this and the probability of a large increase in the amount of ozone at altitudes above 20 kilometers, the results of these measurements indicate that ozone is an important factor in determining the optical properties of the atmosphere and the color of the sky.

* Extracts from a paper published in *Science Progress*

High-speed Bullets and Dumdums

IT is unfortunate that the disposition of a bullet is not always as humane as its appearance. Its failure to live up to its mild looks is responsible to a great extent for the "dumdum" charges that have been fired back and forth between the opposing forces in Europe only a little less frequently than the huge shells.

Queerly enough, the mildest looking bullet among those used by the Germans and the Allies is the one with the most fiendish traits. This, the spitzer or pencil-pointed modern bullet, fired in the German Mauser, the French Lebel, and to some extent in the British Lee-Enfield, is apparently shaped to punch holes in soldiers with the minimum of pain and annoyance to said soldiers. The point looks as if they had put the old style blunt nose bullet into a pencil sharpener and nicely sharpened the point.

So kind-hearted does this sharp nose missile appear that various theoretical parties about the country announced in the public prints that the sole reason for its adoption was to be as humane in shooting the other fellows as circumstances would allow. Unhappily this explanation for the sharp point lacks a minor virtue—that of being true. Experiments by the Germans in 1905 evolved the fact, known fifty years before but forgotten, that putting a very sharp point on a bullet cut down air resistance, as a sharp bow on a boat cuts down water resistance. In turn, this allowed a lighter bullet to overcome air pressure, and therefore to hold its speed as well as a heavier bullet of the old type. In turn, this allowed of higher speeds, because the bullet was lighter and pressure and kick were less, and the higher speeds gave flatter flight of bullet and much increased danger spaces through this flat flight. So came the spitzer.

The French and the Swiss went the Germans one better, and tapered the stern of their bullets also, making them a true boat-shape, that the air might flow back in around them and not drag.

So, instead of advancing the cause of humanity by adopting painless, keen-cutting bullets, the nations taking up the spitzer sought nothing more merciful than hitting still more men on the other side of the argument.

And worse and more of it, the sharp point bullet developed a wounding effect far greater than that of the old, long, blunt nose bullet. The latter practically never did aught but whip through cleanly, never tumbling or upsetting or lacerating or smashing bones. The new bullet with the center of gravity far back and with the point very light and easily deflected, just as is the front wheel of a bicycle, developed an alarming tendency to turn sideways, or to swap ends like a skidding automobile, or to spin on its base like a wabbling top. Any one of the three wrecked tissue and inflicted savage wounds akin to the soft-point bullet used for game shooting, and by the British for use on savages.

Colonel Roosevelt, in his African trip of 1909, was the first truly prominent personage to call to public attention the deceiving nature of a bullet that promised, on the face of it, to make war more attractive. He took with him to East Africa a sporting model of the Government New Springfield, and for this he took both the old, blunt nose bullet, with soft nose for game shooting, and some of the regular Government cartridges with the 150-grain spitzer bullet, just as issued to troops. After a few weeks, lo and behold, he abandoned the old soft-nose ammunition and used the spitzer Government stuff exclusively, for the good reason that it was more deadly! And, mark you, more deadly than soft-nose bullets, specially designed to expand and break up and inflict horrible founds.

Then, in 1910, Stewart Edward White, the noted novelist, sought the East African country, taking with him the duplicate of the battery of the famous Colonel, including some of the soft-nose old-type bullets for his New Springfield, and some regular spitzer 165-grain bullets full jacketed, for the same rifle.

Like his predecessor, he speedily abandoned the heavier, longer, blunt-nose and soft-point bullets, for the full-jacketed spitzer bullets as used by many of the civilized nations. On this first trip he killed over two hundred head of big game. He actually hit 185 head with the Springfield army rifle, and he bagged 179 of these animals, three of those wounded and escaping, being animals going to ground like jackals. Thus practically no animal hit got away wounded, and the deadliness of this bullet was proved superior to even the specially designed capped English big game bullets, made to break up and inflict all the damage possible on flesh.

Some years ago the Russian Red Cross complained to the Russian Minister of War against the spitzer bullet, then just adopted by the Germans and Austrians, alleging that it had been proved beyond doubt that this bullet inflicted needlessly severe wounds by its tipping and wild flight through tissue. Without doubt the high speed of the bullet aids this effect. Without doubt at the longer ranges, 800 yards or more, where the bullet has lost half of its original speed, this effect is not to be found. When you consider a bullet traveling with a velocity of close to 2,900 feet a second and spinning at the rate of over 3,000 revolutions per second, it is easy to understand that if it got to spinning widely on its rear end instead of truly on its axis, the effects would be those of a far larger and more severe bullet.

The term dumdum, used glibly by newspaper correspondents, is not at all applicable to the bullets that may have been deformed or partly sawed through by some misguided people on either side. In the early days of the .303 bore British Lee-Metford, among the earliest of the small bore, high speed rifles, the British found that the small, full jacket bullets would not stop infuriated or fanatical Indian hillmen. The bullets romped right through, delivering little shock except when striking vital parts, and the fanatics hit did not go down. They might die in sixty seconds, but if this time were enough for them to get to the British line and use their knives, the time was too long. So the little British East Indian arsenal of Dum-Dum was given the job of changing around these 0.30 caliber bullets to inflict great shock and stop a charging man.

They did this by cutting away the jacket of German silver, at the point, exposing the leaden core. The impact on the body of a man would cause the lead to flatten out or mushroom, and the jacket to strip or rip back, giving a missile with a great shock-giving power. This was the father of all modern soft-nose, game-shooting bullets. The original dumdum was changed about a bit, being made hollow-nosed, the jacket being cut away at the point, and the core having a hole bored down in it, to cause more ready expansion. This took its place in the line of British cartridges, being known as the Mark IV. While agreements among the civilized powers forbade the use of any bullet, altered or designed to produce expanding or explosive effects, the heathen were not represented, and it was so much the worse for the heathen.

These Mark IV bullets were used on the hillmen of India for years—and maybe yet—and were later used on the dervishes and on the Matabeles of Africa.

But the modern spitzer, at its still higher velocities and its unsteady performance in tissue, gives results that are more frightful than any dumdum. Were this not true, then the African sportsmen never would have abandoned heavy, soft-nose bullets for a lighter, full jacket bullet that could not possibly break up or expand.

Ergo, if the Allies did turn to dumdum bullets they would very probably turn to missiles more merciful and less destructive than the perfectly civilized and authorized sharp point missiles.

It is true that the spitzer bullet does not always go through the same performance. Doubtless this is due to the range. Game is killed under 500 yards; most of it under 200. What the bullet might do at this range, it might not do at all at 800 yards or farther. So, to draw a parallel between our game shooting experience and war, we must also consider the ranges used. This is not to say that the greater number of men hit are not hit at practically game-shooting ranges, but it is to explain why men may suffer severe wounds, or merely clean punctures, from the self-same class of bullets.

National Standard Hose Couplings and Fittings for Public Fire Service*

THE movement for the adoption of standard fire-hose couplings dates from the great Boston fire of 1872, which showed the impossibility of the fire departments of adjacent towns acting in unison when provided with the diverse sizes of hose fittings then prevailing.

The matter was taken up at the first convention of fire engineers, in 1873, and was discussed at various conventions in succeeding years. The resolutions gradually became more definite, although little was accomplished toward bringing about the desired changes until the agitation received a new impetus from the Baltimore fire in 1904, when neither the Washington, Philadelphia, nor New York fire engines, on their arrival could make connections with the local fire hydrants.

This condition led the Merchants & Miners Transportation Company in April, 1904, to request the secretary of the Department of Commerce and Labor to investigate the subject of fire-hose couplings. The secretary referred the matter to the Bureau of Standards, and in the investigation which followed, it was found that there was a great diversity in sizes and threads of couplings throughout the United States. It was evident that considerable expense would be involved in changing from one standard to another, and therefore, at the conference of the committees of the National Fire Protection Association and American Water Works Association, held in New York city, April 24th, 1905, the Bureau of Standards suggested that either the thread most extensively used, or that thread which possessed the greatest advantages in other respects, might be adopted. Following the latter course, the conference resolved that 7½ threads per inch should be recommended for 2½-inch fire-hose couplings. This thread was not regarded as necessarily an ideal standard, but was considered as a practicable basis for unification under prevailing conditions.

At the annual convention of the International Association of Fire Engineers at Duluth in 1905 this standard was adopted after lengthy discussion, and at Dallas in 1906 the convention re-affirmed the action taken at Duluth and made its record complete by adopting the national standard specifications covering couplings of 3 and 3½ inches inside diameter, each to have 6 threads to the inch and a 4½-inch coupling having 4 threads to the inch.

Since then a dozen large organizations have adopted the national standard. The report of the committee of the American Society of Mechanical Engineers, adopted December 3d, 1913, treats its present status in a very clear and comprehensive manner, with suggestions for converting non-standard couplings for serviceable interchange with the national standard. Up to 1914 the national standard had been put into service in 287 towns and cities, either as new equipment or by adaptation of non-standard couplings to interchange with the standard.

* Bureau of Standard Circular No. 50.

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